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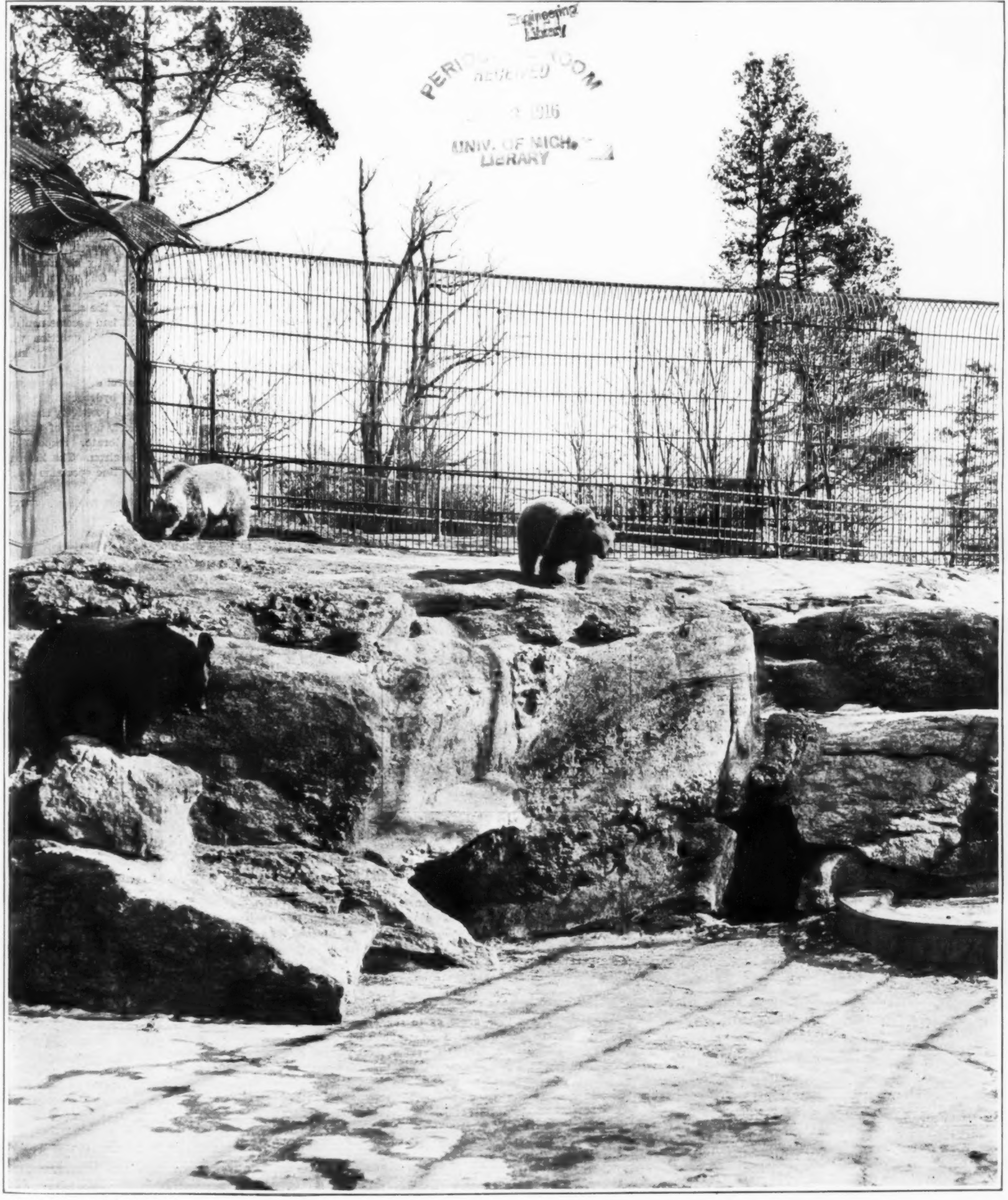


Photo by Courtesy of N. Y. Zoological Society.

The spacious bear den and some of its inhabitants.

THE NEW YORK ZOOLOGICAL PARK.—[See pages 358-61.]

Radiations From Atoms and Electrons—V*

A Study of the Character of the Mechanism Within the Atom

By Sir J. J. Thomson

Continued from Scientific American Supplement No. 2108, Page 339, May 27, 1916

In opening his fifth lecture at the Royal Institution on the above subject Sir J. J. Thomson said that at the end of the last lecture he had pointed out that the Doppler principle provided a method of determining the nature of the system to which were due the various lines observed in the spectrum of a gas. The idea of the method we owed to Stark. In applying it, a discharge tube was used having a perforated negative electrode. The stream of positively electrified particles which passed with great velocity through this cathode into the gas behind, produced light, the spectrum of which was examined. Some of the lines of this spectrum were then found to be displaced from their normal positions, while other lines were unaffected. The character of the results obtained was represented in Fig. 1, which represented the variations in intensity observed in the immediate neighborhood of one of the hydrogen lines.

With this gas there was considerable luminosity in the normal, or "rest," position of the hydrogen line, and this was represented in the diagram by the first peak. Following this there was a comparatively dark space, and then came a second peak, which represented the displaced position of the line. This displacement was produced, on the Doppler principle, by the motion of the luminous particles toward the observer. It would be seen that not only was the line displaced, but it was also considerably broadened, owing to the fact that the velocities of the luminous particles differed among themselves to a very great extent. The light represented by this second peak must have been given out by moving particles, or it would not have been displaced. Hence one of the systems that came through the opening in the cathode was the source of this displaced hydrogen line. The particles thus passing were, however, a very mixed lot. This was well shown by Fig. 2, which showed the paths traced on a photographic plate when bombarded by positive rays produced in air by the method he had often described in that room. Each trace was made by a different system of particles, and it would be seen that not only were these systems numerous, but each gave a trace of considerable length. Consider, for example, the line corresponding to CO. If all the particles of this gas passed through the cathode with the same velocity, the long line shown would have been contracted up into a single bright spot. That the trace was stretched out, in the fashion represented, showed that different particles of this gas had different velocities and hence the different displacements from an axis drawn through the central spot. The velocity of the particles corresponding to any point of the trace could be determined by measuring the vertical displacement, as this was directly proportional to the height above the horizontal axis of the figure.

Returning to the discussion of the Doppler effect the lecturer observed that since heavy particles like those of mercury moved more slowly than lighter ones, the displacement of the spectral lines would be less, so that from the amount of this displacement it was possible to determine whether the particles concerned were heavy or light. Very considerable care was, however, necessary in interpreting the spectroscopic observations. It would be observed that the displaced hydrogen line in Fig. 1 showed two peaks, one of which was much nearer the "rest" position of the line than the other. Actual measurement indicated that the ratio of the velocities corresponding to these two peaks was not very different from $\sqrt{2}:1$. Now this ratio was that which the velocity of an atom of hydrogen would bear to that of a molecule. It had been contended accordingly that the light represented by the displacement in Fig. 1 was given out both by atoms and by molecules of hydrogen.

He did not think that this interpretation was a legitimate one. If we studied the distribution of the velocities in diagrams of the kind represented in Fig. 2, a peculiarity quite analogous to the double peaks in Fig. 1 could often be observed. The hydrogen line, for example, would at first be fairly uniform, but later became beaded at certain places, after which the line became more uniform. Now the centers of the two beads were exactly at points corresponding to velocities having the ratio of $\sqrt{2}$ to 1. Spectroscopic observations would show maxima corresponding to these two velocities, and we would get exactly the appearance of the diagram reproduced in Fig. 1, although the beads in question were produced by the atom of hydrogen, and not by the molecule. The explanation of the peculiarity was that the particle responsible for the lower velocity had acquired its speed while still part of a molecule, but broke up after getting through the cathode. It had therefore only the velocity corresponding to a molecule. These considerations showed how important it was to check the spectroscopic observations. This beaded appearance was often to be seen in positive-ray photographs, and whatever showed as beads on them would be represented as peaks in the spectrum, and might lead, as he believed it had done in the case cited, to an entire misinterpretation of the results.

If the spectrum of hydrogen were observed as described, it was found that the series of lines represented by Balmer's formula were all displaced, and by about the same amount. The second spectrum of hydrogen, to which Balmer's lines did not belong, was also to be seen. This second spectrum was a very complicated one, having an enormous number of fine lines, particularly in the red and the orange, which had the peculiarity that none of them showed any displacement in Stark's experiments, but continued to occupy their normal positions. Only "series" lines were, in fact, displaced.

Fig. 1.

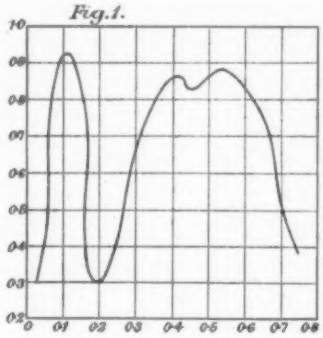


Fig. 2.

An interesting question thus arose as to the origin of the second spectrum of hydrogen. Photographs such as that reproduced in Fig. 2 showed that not merely charged atoms, but charged molecules, came through the perforated cathode. Thus, in the case of hydrogen, we had atoms of hydrogen, molecules of hydrogen consisting of two atoms, and molecules of hydrogen consisting of three atoms. All three were in rapid motion, and any light emitted by them would show the Doppler effect. It followed therefore that the second spectrum of hydrogen could not be given out by anything that came through the hole in the cathode. It could thus not be attributed either to the positively-charged atoms or to positively-charged molecules, and must have as its source something that had not passed through the cathode. Possibly it arose from the vibrations of a molecule one of whose atoms was positively and the other negatively electrified. That this second spectrum was certainly not due to the positive rays themselves could be shown by causing positive rays of one gas to bombard the molecules of another. This had been done by perforating the cathode by a very fine hole, and making this hole the only means of communication between the two sides of the cathode. By means of a pump it was possible to prevent any appreciable intermixture of the gases on opposite sides of the cathode. The positive rays were then provided entirely by particles of the one gas, and spectroscopic observation showed that all the lines corresponding to this gas were displaced, while those belonging to the other gas all occupied their normal positions, and were not displaced. This was, of course, exactly what would have been expected, but it was always pleasing to have such anticipations verified by actual experiment.

It would be seen that while the spectroscope served as a very powerful instrument of research, there was some little difficulty in drawing really definite conclusions from the observations made. One point, in fact, was still in a state of acute controversy—viz., were the lines of, say, hydrogen given out by the atom while it was positively electrified, or after it had become neutral by reacquiring a negative charge. This question was still debated, and it could not be said that any kind of unanimity of view had yet been arrived at. It would, however, require very powerful evidence to make us believe that the line spectrum of hydrogen was emitted while the hydrogen atom was still positively charged, since we had, in the Zeeman effect, means of finding out the nature of the actual vibrator responsible, whether it were an atom or an electron. The Zeeman effect showed conclusively that the line spectrum originated in vibrating electrons.

Now data drawn from many independent sources gave reason for the belief that a neutral atom of hydrogen contained only one electron, so that it was not possible to take out more. The positively-charged atom of hydrogen was accordingly one which had lost its electron. Hence very strong evidence would be required to establish the view that it was a positively-charged atom of hydrogen which was the source of the line spectrum.

The speaker's own view was that both the contending schools were, in a sense, right. To get the line spectrum it was necessary for the atom to have lost its electron so as to become positively charged, but it was only as an electron came back that the light was given out in the process of the atom becoming neutral. This union of the positively-charged atom with an electron was made, more particularly, during the instant of a collision with a molecule of the gas through which the atom was moving. Professor Strutt, for example, had subjected the gas bombarded by the positive rays to a strong electric field, which would have the effect of driving out any free electrons. He found, and similar experiments made by the speaker gave the same results, that the brightness of the lines produced was very little diminished by the action of the field.

Referring back to Fig. 1, it would be seen that there was a marked gap between the normal and the displaced position of the hydrogen line. Apparently nothing less than a certain displacement was to be obtained. Again, as the velocity of the particles was increased we appeared to approach a second limit, as it had not been found possible to get more than a certain displacement of the line even when the theoretical velocity of the rays was much greater than that necessary to produce the maximum displacement observed. Now it was well known that to ionize a gas the speed of the positive rays must exceed a certain limit. On the other hand, if the speed were too great there was very little ionization. The actual luminosity would accordingly appear to be due to the return to neutrality of the positive ray in the act of ionizing the molecule of the gas with which it collided.

A still further advance in the application of the Doppler principle to the study of the origin of luminosity had been made recently by Fabry and Perot. Their method was founded on one of those ideas, which, like the echelon grating, one would consider impracticable until it was actually made to work. These experimenters had applied Doppler's principle to the study of the luminosity of a gas by observing the broadening of the spectral lines due to the motion of the gaseous particles. These were in continual motion,

*From *Engineering*.

some moving toward an observer, and others away from him. The result was a broadening of the spectral line by an amount depending on the speed of the particle, and, as Lord Rayleigh had observed, the actual breadth corresponded very fairly with the average velocity with which the molecules were moving through the gas. If, therefore, the origin of a spectral line were a light atom, this would have a very high velocity, and the widening be correspondingly great. If a heavy atom were responsible, the widening would be less. Hence accurate measurements of the widening would suffice to determine the average velocity of the particle responsible for the emission. Then from the law that all particles in a gaseous mixture had the same kinetic energy the mass of the particle could be determined. This beautiful conception was the more important because so many lines showed a velocity effect. The only point open to suspicion in the experiments in question was whether a charged particle would have the velocity normally due to it. This could be settled by a comparison with results obtained by Stark's method in conditions in which both methods were applicable. If the reliability of the new plan was thus confirmed, full confidence could be placed in the interpretation that Messrs. Fabry and Buisson put on their results. If the method really did give the velocity of the atom bearing the vibrating system which was responsible for the spectral lines, the method could be applied to many cases where Stark's plan could not be used.

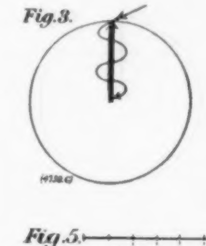
As he had already mentioned, the Zeeman effect showed the nature of the source from which light was emitted, whether it were due to an electron or to a body of very much greater mass. In this connection, however, it should be noted that to produce visible light the electron must be associated with an atom, since direct radiation from a free electron had never yet been observed in the spectroscope. Were this possible, the displacement would be enormous, owing to the immense speed of the electron. The Zeeman effect had, however, no reference to free electrons, but only to electrons associated with an atom.

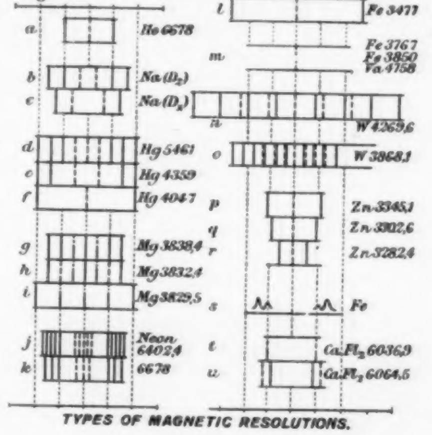
Faraday, years ago, had sought to discover some effect of magnetism on light. He did find that a magnetic field could be made to rotate the plane of polarization of polarized light, but he had failed to observe any effect of magnetism on the light given out by, say, a sodium flame. Effects of this kind had, however, been discovered by Zeeman on studying the spectrum of various substances as excited by a spark passed between the poles of a very strong magnet. Zeeman found that in strong fields the lines observed were not in the same position as they were when the magnetic field was absent. Single lines were broken up, in the original experiments, into three components. More extensive study had, however, shown that the type of resolution effected varied considerably, being in certain cases very complicated.

This power of a magnet to resolve a spectral line into components depended upon the mass of the particle responsible for the emission being exceedingly small. In fact, investigations made prior to Zeeman's experiments gave expressions which led to the idea that the light emitted in a magnetic field should not be quite the same as normally; but when these expressions were expressed numerically, it appeared that, assuming the emitting particle to have the smallest mass then known, the effect would be so minute that it would be hopeless to look for it. At that time, in fact, there was no knowledge as to the existence of particles smaller than the atom, and Zeeman's success was due to the fact that such particles or corpuscles actually existed.

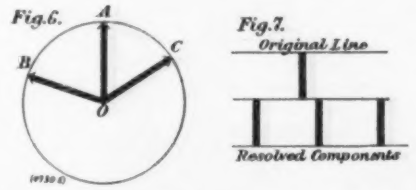
The lecturer here showed the effect of a magnetic field on the corpuscles moving in a discharge-tube. With no magnet near, the particles, he observed, moved in a straight line; while the effect of bringing near the discharge a strong magnet was to curl round their paths into circles or spirals having the lines of magnetic force as axes. When these particles spun round the lines of magnetic force in this way, a peculiarity of the motion was that the time taken to complete one revolution was always constant. It did not matter how big the spiral might be nor how small. If close in to the axis the particles moved more slowly, while if farther out the speed increased, with the result that the time for a complete rotation was constant. In short, the number of rotations made per second was proportional to the expression $\frac{He}{m}$, where H denoted the magnetic force, e the charge of electricity borne by the particle, and m its mass, so that in a uniform field the time depended solely on these three quantities. Suppose, now, that inside the atom represented by the circle in Fig. 3 there was a magnetic field the direction of which was represented by the vertical line shown. An electron falling into the atom would describe a spiral around this axis of magnetic force, and throughout its motion the rate at which it revolved would be proportional to $\frac{He}{m}$. It would therefore radiate out a spectral line having the corresponding frequency.

The magnetic force represented in Fig. 3 was assumed to be that intrinsic to the atom; but suppose an additional field H_o, due to an outside source, were established, and let this field be parallel to the atomic field. Then, if the two fields were in the same direction, the particle would make, not $\frac{He}{m}$ turns in unit time, but $\frac{H + H_o}{m} e$ turns. On the other hand, if the two fields were in opposite directions, the number of turns made would be $\frac{H - H_o}{m} e$, and the frequency of the light emitted would be less than if the external field were canceled. On the other hand, if the ap-





TYPES OF MAGNETIC RESOLUTIONS.



plied field were perpendicular to the intrinsic field, the turns made by the rotating electron would be unaffected. Hence, in a magnetic field the frequency of some of the electrons would be increased, the motion of others would be retarded, while for a third set it would be unaffected. Hence by superimposing a field on that due to the atom itself we should alter the time of vibration of the light given out, and instead of the normal single line we should get three lines, one in the original position and the others displaced from this by an amount proportional to $\pm \frac{H_o e}{m}$.

In the foregoing he had used the idea of a magnetic axis intrinsic to the atom for descriptive purposes, but he did not propose to press the idea at this time.

As he had already stated, further research on the Zeeman effect showed the resolution of spectral lines into a great number of different types. A number of these were represented in Figs. 4 and 5. In the simple type shown at the top of Fig. 4 one line was resolved into three components. This was the case with helium and with some of the hydrogen lines, and was especially common with the lighter elements up to lithium. With sodium, as the diagrams showed, there was greater complexity, one of the lines being split into five, and the other into four components. In the case of the mercury spectrum it would be seen that some lines divided into three, others into six, and a third set into nine components. The noteworthy point was that all the lines belonging to the same series underwent the same type of resolution. In the case of neon, the resolution was, it would be seen, of an extraordinarily complex type. On the other hand, in the case of iron (Fig. 5), one line was not broken up at all, while others were resolved into as many as five components. The resolution of a line showed that it came from an electron, and not from an atom, which was much too heavy. Band spectra did not show the Zeeman effect, which was to be obtained with line spectra only. It had been found that some lines in the second spectrum of hydrogen were affected, but the vast majority of the lines in this certainly did not show the effect.

If one took the view that there were magnetic forces inside the atom, the variety of types of resolution obtained could be explained on the hypothesis that there were axes of magnetic force in an atom, somewhat similar to the axes of a crystal. Suppose these axes of magnetic force were represented by $O A$, $O B$, $O C$, Fig. 6, and let the applied field be parallel to $O A$. The component of the external field along $O C$ would then be $H_o \cos \theta$, where θ denoted the angle between $O A$ and $O C$, so that while the applied field would accelerate or retard electrons spinning about the axes $O A$ by $\frac{H_o e}{m}$, the corresponding acceleration or retardation for $O C$ would be $\frac{H_o \cos \theta e}{m}$. This showed why the displacement for all the lines was not of equal magnitude, which was a difficulty in some theories which had been put forward to explain the Zeeman effect, as they gave the change of frequency in all cases simply as $\frac{H_o e}{m}$.

To illustrate the Zeeman effect the lecturer passed polarized light through a salted flame placed between the poles of an electro-magnet, thence through a nicol prism, and on to a screen. By rotating the nicol the light on the screen was extinguished, but on then exciting the magnet the spot of light reappeared, indicating that the magnetic force had altered the frequency of the sodium light.

He also exhibited a model which, from the mathematical point of view, corresponded, he said, very closely to the motion of an electron in a magnetic field. In traversing a magnetic field such a particle was subject to a force at right angles both to the field and to the direction of its motion. The model consisted of a conical pendulum, the bob of which was a gyroscope. With the gyroscope not spinning, the periodicity of the pendulum had a certain value, which was, it was shown, the same in whichever direction the pendulum moved. When, however, the gyroscope was spun, the rate of rotation of the conical pendulum was greater than the normal if it moved in one direction, and less than the normal if the direction were reversed. The forces acting on the spinning gyroscope while the pendulum rotated were, the lecturer said, of the same character as those to which an electron was subjected in traversing a magnetic field.

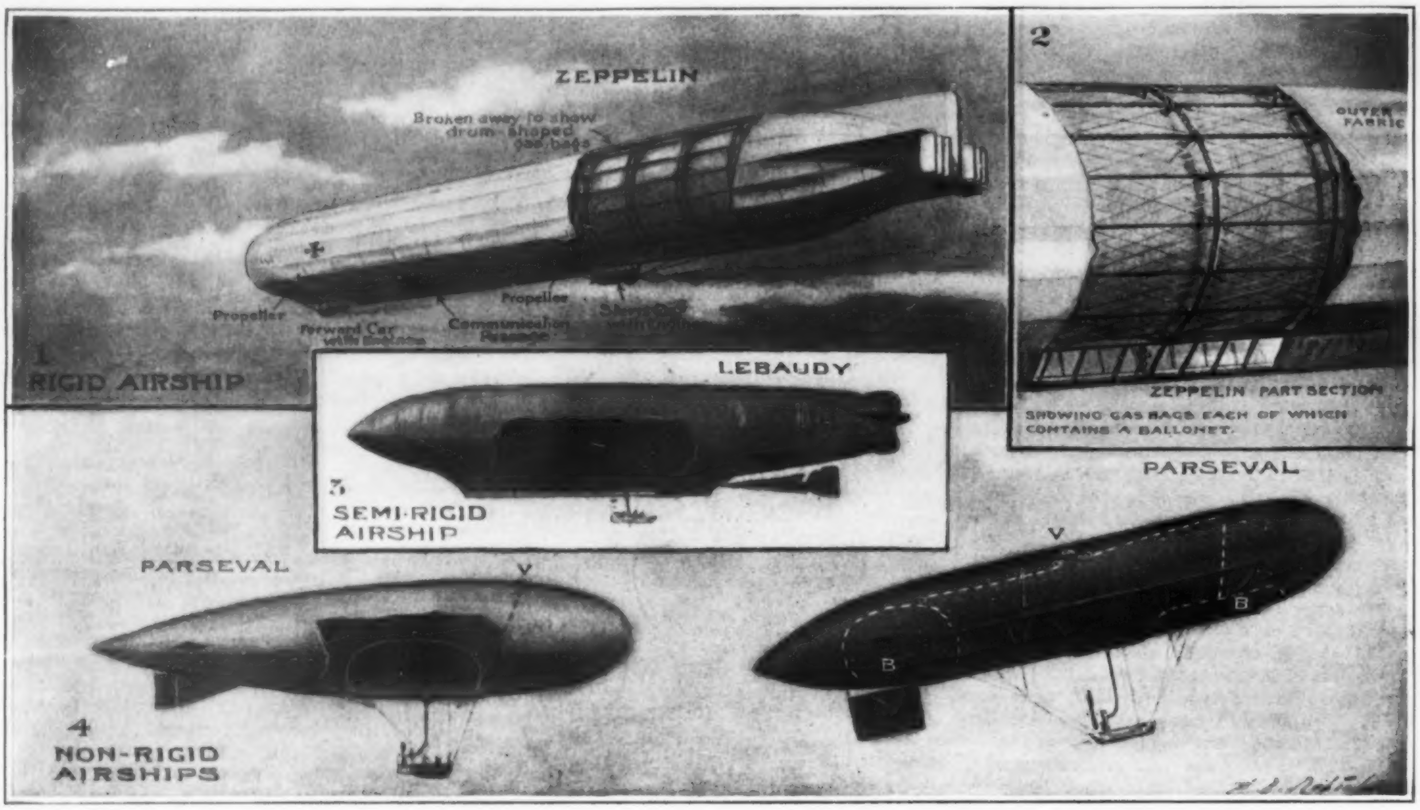
Within the last two years Stark had discovered another effect produced when the spectral lines were emitted in an electric field. It was difficult to establish a strong electric field in most of such discharge-tubes as were used for spectroscopic work. Stark had, however, succeeded by placing close behind the cathode a perforated plate, the interspace between the two being small compared with the "dark" space of the tube. Connecting up the cathode and the plate, with the opposite poles of a battery, a very intense field was produced between the two, which it was found possible to carry to thousands of volts per centimeter without causing a discharge.

In these conditions Stark noted that certain of the hydrogen and helium lines were affected, being split up in a fashion somewhat analogous to, but by no means identical with, that observed in the case of the Zeeman effect. For example, a line was divided into a triplet, as indicated in Fig. 7; but not one of the three components was quite in the same position as the original line. The components were, moreover, polarized in some cases in a plane at right angles to the electric force, and in others in a plane parallel to this force. The effect was, however, by no means so common as the Zeeman effect, and was of a very irregular character. Sometimes the whole of the components produced lay to the one side of the original line, and in many more cases the effect was altogether absent. In the speaker's opinion, the phenomenon had more to do with the nature of the atom concerned than with the character of the vibrators responsible for the emission of the light.

(To be concluded.)

Regenerating Hydroquinone Developer

The *Phot. Jour.* states that the quinol of a spent developer may be recovered by reducing with sulphur dioxide and then distilling with steam to separate the impurities. A developing agent may be obtained in the same way from any spent developer in which a para-substituted benzene derivative has been used, but in most cases it will not be the original developer.



Courtesy of The Illustrated War News.

Airships: Rigid; Semi-Rigid and Non-Rigid*

Some of the Internal Details of Vessels Now in Use

The general principles on which an airship is constructed are too well known to need any detailed description, but there are some internal details which are of outstanding interest.

Airships may be divided into three types: rigid, semi-rigid, and non-rigid. In the first of these, of which the German Zeppelin (Figs. 1 and 2) is the best known example, the gas bags are enclosed in a rigid lattice framework of metal, having an outer covering of fabric distinct from that of which the gas bags are composed (Fig. 2). The modern Zeppelin is supported by about eighteen separate gas bags, each of which contains within itself a small air-ballonet, in which the air pressure is maintained at a given point by means of an automatic air-pump and relief-valve. If, therefore, the temperature of the hydrogen in the gas bags becomes high enough to expand the gas, the pressure set up by it on the outside of the ballonet (not seen in the diagrams) forces the air out of the ballonet through the relief-valve, and the correct pressure is in that way adjusted without loss of hydrogen. The converse happens in case the temperature of the hydrogen falls, and its bulk for that reason becomes less. The air-pump then forces the air into the ballonet, and expands it until the hydrogen round it is brought to the correct pressure. When it becomes necessary to reduce the buoyancy of the machine, hydrogen can be pumped from the gas bags and stored in a compressing cylinder, this hydrogen being available for use later, when desired to again increase the buoyancy. By the simultaneous manipulation of horizontal rudders and "trimming" devices and the discharge of ballast, a Zeppelin can shoot up to a higher level at the rate of 2,000 feet per minute, the vessel's engines in this case assisting the lifting power of the gas. This speed of ascent makes it very difficult for an aeroplane to attack one of the machines successfully from below, as it cannot climb at anything like the same speed; but this maneuver on the part of the Zeppelin cannot be repeated indefinitely, owing to lack of spare ballast.

The Lebaudy airship employed by the French is an example of the semi-rigid type (Fig. 3). In this design a substantial keel extends almost to the full length of the vessel; and to this keel is attached the machinery, together with the accommodation arrangement for the crew. The keel is securely fixed to the gas bag above it, to which it gives very considerable support. In the German service the Gross airship is another of this type. The envelope of a non-rigid airship keeps its shape only by the pressure of its gas, the car carrying the machinery, etc., being suspended below (Fig. 4). The German Parseval, French Clement-Bayard, and the Astra Torres are all examples of this type.

*The Illustrated War News.

The Parseval gas bag is provided with an air-ballonet in its forward end and another aft (diagram right hand Fig. 4, *B B*), the amount of air in each of these ballonets being controlled by a pump in the car. When it is desired to alter the trim of the vessel, air is transferred from

Fig. 5.—Section of the gas-bag of the Astra Torres (non-rigid type).

the container in the forward end to the other one, with the result that the after-end of the ship becomes the heavier (as in figure). A cord attached to the exterior of the ballonets passes through the hydrogen to a valve

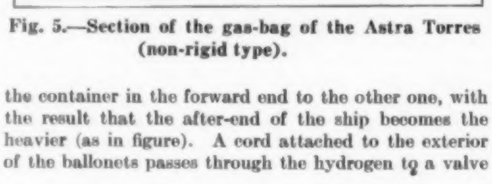


Fig. 6.—Section of the Astra Torres to show the arrangement fo the cables inside the vessel.

in the exterior of the gas bag. If the hydrogen expands to such an extent that the combined capacity of these vessels is insufficient to relieve the excessive pressure, their collapse causes a strain on the cord which opens the relief-valve in the gas bag and allows some of the hydrogen to escape. This device, however, only comes into operation in very extreme cases.

The Astra Torres gas bag is of a peculiar section, as shown in Fig. 5. Permeable canvas partitions (*AA*) are stretched across the interior of the bag which form in section an inverted triangle. The apex of the triangle (which in this case is at the bottom) supports the cable carrying the cars containing the machinery, etc., and the sides of the triangle are therefore strengthened by planes of cable (Fig. 6). The Astra Torres has proved to be very fast and efficient, its qualifications in this direction being to some extent accounted for by the fact that the air-resistance on the cables is reduced to a minimum. Only two lines of ropes are exposed, as compared with the cobweb of ropes which is to be found in all other types of non-rigid machines.

Earthquakes in California

In a paper in the *Bulletin* of the Seismographical Society of America Andrew H. Palmer, of the U. S. Weather Bureau, states that "during the past year California alone experienced more earthquakes than all the rest of the United States. Though it contains but 5 per cent of the area of the whole country, it had more earthquakes than the remaining 95 per cent of the area. Up to November 1st California had 75 separate and distinct shocks, while but 68 shocks were reported from the rest of the United States. A region of high seismicity derives its instability from a number of causes, among which the following are the most important: (*a*) Folds in the earth's crust, either emerged or submerged; (*b*) marked variations of topographic relief; (*c*) great ranges between ocean bottoms and adjacent mountain tops, as found where high mountains are close to a coast where the ocean bottom slopes precipitously to great depths; and (*d*) regions where secular elevation or depression is still in progress. All of these features are present in California, and collectively explain its relatively high seismicity. While the seismicity of the State is acknowledged to be high—the highest in the United States—the actual danger to one living in any particular locality is small indeed. Though written thirty-five years ago, the following words of General Hardenburg are still true: 'Reasoning from the foregoing historical facts, I am firmly of the opinion that the earthquakes of California are not so much to be dreaded as is generally supposed; in fact, that they are far less dangerous to life and property than are the hurricanes of the South, or the summer tornadoes of the North.' It would appear that the relatively high seismicity of the San Francisco Bay is the direct result of its location on two different stress planes which cross nearly at right angles."

New Enlarging and Projection Apparatus

In order to be independent of daylight, the "daylight enlarging apparatus" for negatives has been replaced by one in which artificial light is used. But by its use the advantages of diffuse light are lost, and the homocentric light sources (lamps) of the forms of apparatus usually used, in which the light comes from a point, are liable to cause the enlargement to be "harder" than the original negative. The enlargement of comparatively dense negatives in this manner is almost impossible. The problem has been solved in an ideal, simple way by a new apparatus from Schmidt and Haentsch of Berlin, which makes use of artificial diffuse light. A hollow sphere painted white inside and illuminated within by powerful metal filament lamps is used as a source of light. A rectangular opening in the sphere allows the white diffuse light to escape after it has been reflected from the white matte or dull finish walls of the interior, and it is then used for the enlargements. The lamps within the sphere are of course so arranged and constructed that no direct light escapes through the opening and falls on the negative. Fig. 1 shows the arrangement of this very convenient piece of apparatus. *H* is the hollow sphere, on which the socket for one of its interior lights is seen. The enlargement apparatus is attached to the rectangular opening in the sphere, and the whole apparatus may be moved about on the track *L*. The sensitized paper on which the enlargement is to appear is then placed perpendicular to the direction of the slide *L*. Fig. 2 shows the same principle applied to projection apparatus for opaque objects, such as drawings, prints, and pictures from printed matter. The apparatus may be placed with the opening in its base directly over the image which is to be projected. The lamps, which are in a condensed form so that they do not interfere with the field of the light, illuminate the inner white surface of the sphere. The light falling directly on the image is blended by small matte-glass shields so that the light entering the lens system on the opposite side can reach it only by diffusion. A surface-silvered mirror receives the light from the image and directs it to the projection screen. In contrast to the complicated pieces of apparatus for similar purposes (episcope), this arrangement is characterized by its extreme simplicity. The usefulness of this spherical episcope can scarcely be exaggerated. By proper arrangement of the matte-glass shields to protect the object from any direct light, crumpled gold leaf can be made to lose all glitter by illumination with diffuse light. A mirror appears as a piece of paper, and a shining metal statue like a plaster of Paris figure.—*From Rundschau.*

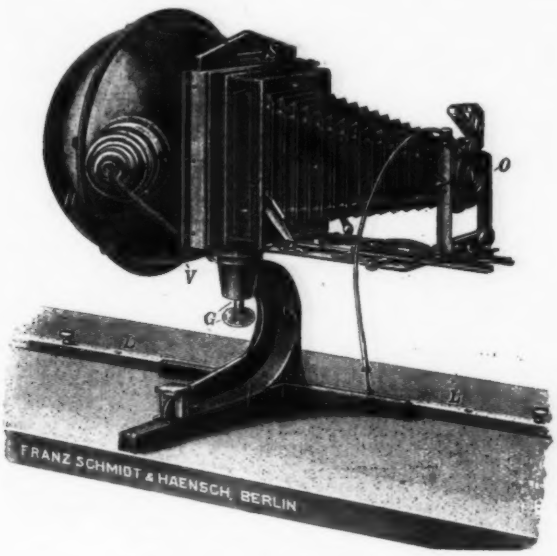


Fig. 1.—Apparatus for photographic enlarging by diffused artificial light.

Fig. 2.—Apparatus for enlarging or projecting opaque subjects.

Aviation Sickness, Its Symptoms and Cure

Those who go up into the air in flying machines, as well as those who go down to the sea in ships, are troubled by peculiar and unpleasant physiological disturbances which may at times be of grave moment. This is especially true of aeroplane pilots or passengers, and, to less degree, of those who ascend in balloons or dirigibles. The tremendous importance of aviation in war lends this subject peculiar interest at the present time, and *Larousse Mensuel* (Paris) devotes a special article to the topic. The author, Dr. Laumonier, states that the symptoms vary according to the period of of ascent, of descent, and of landing.

In ascending, an acceleration of the respiration and pulse are frequently noted at from 1,200 to 1,500 meters altitude, accompanied by a slight headache located in forehead and temples, by the need to urinate and by indefinable discomfort without vomiting or nausea. At 1,800 meters there is a diminution in the keenness of hearing; at times there are hallucinations, and finally an "asthenic" condition which prevents the muscles from obeying the will with adequate rapidity.

On descending the palpitations of the heart become violent and are accompanied by a sensation of anguish; the headache is intense; the aviator has an increasing sensation of heat of the skin, especially of the face, and a desire to sleep, which is sometimes so strong that the eyes involuntarily close as he approaches earth, in spite of imminent peril.

Strange to say, on landing these troubles are augmented. Besides, the headache and the somnolence, hyperemia of the conjunctive (conjunctives) is observed, with cyanosis of the extremities, acceleration of the pulse and constant increase of arterial pressure. The aviator often falls asleep as soon as he lands, and this sleep is troubled and non-refreshing, while the headache may persist for many hours or even several days.

The ascent symptoms recall those of "mountain sickness," but are produced at a less altitude, because of the nervous tension, the cold, and above all the relative rapidity of ascension. But what distinguishes aviators' sickness from mountain sickness is that the symptoms persist during descent and are aggravated after landing. There are, besides, vaso-motor reactions with hypertension which are peculiar to this malady, and give it, according to Cruchet and Moulinier, a sort of nosographic autonomy. However, these troubles are not felt with the same intensity by all aviators. Some find they diminish with experience, as in the case of *mal de mer*. It appears to be true that their intensity depends principally on the rapidity of the descent.

The causes to which are ascribed these symptoms include cold and physical, nervous, and moral fatigue. While cold may provoke the impervious need to sleep, it cannot be the sole cause, since the somnolence increases on descending into warmer air and after landing. Analogous objections are made to fatigue as a cause, since it has been observed in those taking part in sports that fatigue produces vascular hypotension, while the opposite trouble of hypertension is constant in "*mal des aviateurs.*"

The most important of the determining causes, according to the authorities quoted above, is speed; not horizontal, but vertical speed, which causes rapid decompression and recompression in ascending and descending. At Pau, Legagneux ascended to 3,200 meters in 28 minutes, whereas it would have taken an alpinist 11 hours to ascend the same distance on foot. The characteristic troubles of aviator's sickness are evinced specially during and after descent is succeeded by the very rapid recompression of descent. At Varenne-sur-Allier Vedrines descended in 3 minutes from a height of 3,000 meters. The difference of gaseous tension is too great for the organism to regain its equilibrium in so short a time. This explanation is supported by the experiments of J. Tissot on inhalation of air unequally oxygenated, and by observations of divers.

Since these symptoms are not morbid they disappear naturally in a few hours or at most a few days, their cessation being favored by rest, sleep, and moderate warmth. Nevertheless, they are of grave importance because of the dangers to which they expose aviators, especially as they are about to land. Hence, it is highly advisable that fliers should be young, robust, resolute and cool-headed men, with sight, hearing, nervous and vascular systems perfectly sound. And there should be rigorous elimination of candidates who have a tendency to heart trouble, epilepsy, tuberculosis, hardening of arteries, nervous troubles, etc. They should have methodical and progressive training, a diet nourishing but not bulky, and as little fermentable as possible. They must abstain from alcohol and not abuse tea or coffee. The clothing must be very warm but not heavy enough to restrict movement. The wearing of goggles, putting cotton in the nostrils and greasing face and hands will be sufficient protection against cold. Finally, they are advised to mount as slowly as possible and to descend even more slowly.

Refraction and Accommodation in the Dog's Eye:—A Correction

By H. M. Johnson

In a note which recently appeared in this journal[1] the writer asserted, on the authority of Freytag, that the refractive indices of the lens and fluid media of the dog's eye are practically identical, and that several other species of infra-primate mammals suffer under the same condition. If this assertion were true, its significance would be very great indeed, since in such case the animals concerning which it is made could not change the focal distance of the eye by any mechanism of accommodation which mammals are known to possess.

At the time my note was published, I had been unable to procure a copy of Freytag's original article.[2] My assertion was based on my acceptance of a reference made by an American compiler to Freytag's work, in which a series of values were presented in tabular form as Freytag's. A comparison of the latter with the original article, which I have since obtained, shows that Freytag was incorrectly quoted by his reviewer, although the error is clearly unintentional. Freytag actually gives as mean values of the refractive indices in young and old dogs: for the aqueous humor, 1.3349; for the vitreous humor, 1.33483; and for the lens, values ranging between 1.4498 and 1.46[illegible]6, depending on age. These differences are greater than those obtaining between the refractive indices of the lens and fluid media in the human eye, and are comparable with the differences found in the other mammals which Freytag studied.

In the individual dog which I studied no clear evidence of accommodation could be obtained. Momentary fluctuations in refraction varying from 0.25 to 0.75 D occasionally appeared during a prolonged examination. These may have been caused by accommodation, but they are as readily explainable on other assumptions. The facts are quite consistent with the results obtained by Boden,[3] who refracted the eyes of 100 dogs both before and during mydriasis.

These individual dogs apparently make little or no use of their mechanism of accommodation. If this is generally true of dogs as a class, it would seem that the defect is retinal rather than in the accommodatory apparatus itself. If it may be assumed that the stimulus to accommodation is indistinctness of the retinal image, it is evident that an animal whose retina is relatively insensitive to detail would have relatively slight stimulus to accommodation.

As regards the conclusions which I drew from the experiments reported in the above note, I still feel quite safe in applying them to the dog. They cannot properly be extended to cover other infraprimate mammals, however, until more is known about the extent and range of accommodation in the latter.

[1] "Visual Pattern-discrimination in the Vertebrates. V. A Demonstration of the Dog's Deficiency in Detail Vision," in "Notes from the Nela Research Laboratory," *Journal* of the Franklin Institute, December, 1915.

[2] Freytag, G.: "Die Brechungsindices der Linse und der Flüssigen augenmedien bei der Katze und beim Kaninchen," *Arch. f. vergl. Ophthalmologie,* vol. 1, 1909-10.

[3] Boden, Rudolf: "Ueber den Refraktionszustand des Hundeauges," *Arch. f. vergl. Ophthalmologie,* vol. 1, 1909-10.

Editor's Note.—*The original article referred to in the above note was republished in the issue of the* Scientific American Supplement *of May 13th, No. 2106, and the above correction will be appreciated by our readers. It should be noted that in the second column of the article, as it appeared on page 315, the compositor made the matter read "a visual angle of 33 feet 32 inches," whereas it should have read "a visual angle of 33′ 32″."*

The New York Zoological Park

One of the World's Most Notable Institutions

By Dr. R. W. Shufeldt

ALTHOUGH not possessing the acreage of the National Zoölogical Gardens at Washington, the New York Zoölogical Park here to be described ranks it many times in every particular pertaining to one of these important institutions.* In the first place, it is far better taken care of financially; and to maintain a great park of this kind as it should be done the matter of sufficient money is the all important factor. Added, then, to its wealth, we find skillful and judicious directorship, and a most superb collection of rare and valuable animals brought together from all parts of the world. Finally no zoological garden known to me possesses such elaborate and substantial buildings as does this one nor more attractive and tastefully laid out premises. Indeed, it is scientifically equipped in all particulars, and represents the highest possible standard with respect to capable management and far-reaching educational achievement. It is truly marvelous what the authorities have accomplished in all directions since the Legislature of New York State granted, in 1895, a charter for the incorporation of the New York Zoölogical Society, in which body this park found its origin.

The society now numbers over two thousand members; and it was not until three years after its incorporation that it assumed control of this enterprise, the first building undertaken being the Bird House (August 11th, 1898); the construction of the Wild-Fowl Pond was commenced only a few days thereafter. It was fortunate that, in the early administration of its affairs, an arrangement was arrived at through which all net profits from all sources, as its restaurants, riding of animals, sale of guide and other books, boat hire, photographs, and other revenues formed a common sum, every cent of which was to be used for the purchase of new animals for the collection. This accounts for the wonderful accessions that are constantly being made along these lines; admission fees, guide-books and photographs alone realize a very tidy sum annually, to which, be it said, through mismanagement in these matters, much of the poor showing of other gardens is due. Of the 264 acres comprising this Garden, there are about 34 acres in water surface, which include the ponds, and the Cope, Agassiz and Bronx Lakes. The Park is most conveniently situated in the northeast part of the city, being readily accessible by several lines of cars and broad highways for automobiles and other conveyances. It is no wonder, then, notwithstanding the fact that two days in the week an admission fee of 25 cents for adults and 15 cents for children under twelve is charged, that thousands of visitors pass through its gates annually, many of them purchasing the "Guide Book" at a cost of 25 cents per copy. This little book almost possesses the rank of an elementary treatise on general zoölogy, in so far as brief life-histories of animals are concerned. It is one of the most complete books of its kind ever published, and of inestimable value to the visitor who goes to the park, not only to see the animals but to study them intelligently.

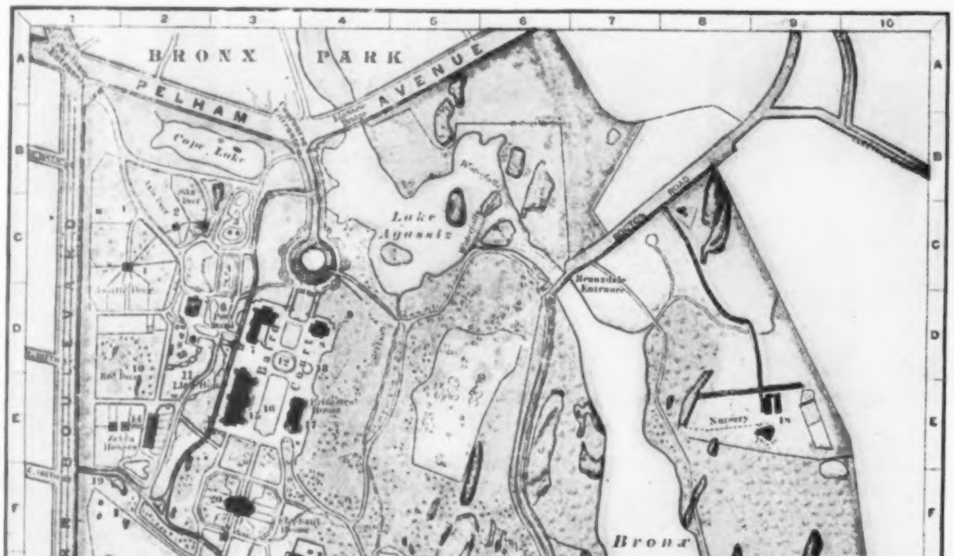
Every manner of convenience is supplied by the authorities and management of this institution; indeed, anything which may conduce to the comfort of the visiting public is at hand. There are wheeled chairs for those desiring them; a first-class restaurant, and a charming sheet of water in Bronx Lake for the use of excursionists and boating-parties, with every facility to enjoy it. The park is nearly a mile in length, and three-fifths of a mile in width. About one-third of this is covered by a magnificent forest of more than a dozen different varieties of trees, including five kinds of oaks, to say nothing of the elegant hickories, gums, tulip-trees, and nearly forty species of shrubs, all of which, as well as the flora of the place, is under the constant care of an experienced forester and botanist.

It would certainly be highly detrimental to the health of this estimable officer should he live to see, in the scientifically kept grounds of this park, the scenes to be witnessed in the National Zoölogical Park at Washington on "Easter Monday," when thousands of negro children with their parents and others, many half-blood, and a fair percentage of whites, resort there to *roll eggs* down the "Mammal-House Hill." It will not be necessary for me to describe the plant destruction that takes place on this "red-letter day;" it can be easily imagined, and space will be saved through the non-description of the scenes that follow such a barbarous practice.

Speaking of the beautiful plant growth in the Bronx and the grand forests to be found there, Doctor Hornaday tells us that "It is safe to say that nowhere else within fifty miles of New York can there be found any more beautiful forests than those in the central and eastern portions of the park. Throughout the inclosed grounds it is absolutely necessary that visitors should be restricted to the walks; for otherwise the feet of our millions of visitors would quickly destroy every ground plant." (Guide-Book, p. 23.)

It is truly marvelous what has been accomplished since this enterprise was first launched. In only a few years, comparatively, through the unstinted financial aid of New York city, Doctor Hornaday's persistent push and exceptional knowledge of requirements, and the general management, we now have a garden, from practically a primeval tract of land, which possesses no rival anywhere in the entire world; and for botanical features, beauty of design, general attractions, and a thousand interests along other lines, it is simply a marvel. There are over a dozen structures absolutely palatial in their designs and in the grandeur of their immediate surroundings. Among these are the Elephant House, the Lion House, the two buildings for birds, several buildings for different species of mammals, the Administration Building and the Reptile House. More than $2,000,000 has been expended by the city in assisting to erect these modern animal palaces; and in addition to these modern, upward of *thirty* other buildings, ponds, pools, paddocks, and the rest, with others for winter-quarters, boat and store houses. Many of these are to be seen in the reproductions of the photographs illustrating the present article; and I may state that there are no buildings of the kind to equal them in any zoölogical garden, either in the Old or the New World.

Another item to be considered is the fact that the Zoölogical Society, to help along the development of this grand institution, has added over half a million



Plan view of the New York Zoological Park.

*The map and all of the illustrations used in this article are copyrighted by the New York Zoölogical Society, and their use in the present connection has been courteously allowed by Doctor Hornaday and the aforesaid society—a privilege not to be extended beyond their appearance here without the issuance of a similar permit.—R. W. S.

more dollars to the fund; in fact, the financial resources of this park are practically limitless—hence the exceptional beauty of its grounds, its extraordinary structures, and its long list of all kinds of animals from all quarters of the globe.

Seven or eight years ago there were upward of 6,000 specimens of animals in the collection, and these were constantly being added to by purchase and by donation.

Personally, I am most emphatically of Doctor Hornaday's way of thinking when he says: "For humane men and women there is small pleasure in the contemplation of living creatures that are in prisons, and that look and feel like prisoners, pining behind their bars. Better no 'Zoos' and no wild animal collections than miserable and unhappy prisoners. A *badly-made* or *badly-kept 'zoo,'* or *zoölogical garden or park, is worse than none.* But, at the same time, it is folly for any one to say that all zoölogical gardens and parks are dens of cruelty, as is held by a few extreme humanitarians. The creatures in the collections of the Zoölogical Park give unimpeachable testimony to the contrary. If our bears, our hoofed animals, our birds and our apes and monkeys are not positively happy, and full of the enjoyment of life, then none are in this world, either captive or free. To-day the life of every free wild creature is constantly filled with alarm, with flyings from danger, and with the daily struggle for food, water and safety. Every hunter knows that after every mouthful of food, the wild animal or wild bird looks about for dangerous enemies; and the ultra-humanitarians take small note of the millions of wild lives that are pulled down and destroyed by predatory enemies."

With this small city of elegant animal buildings and other structures; its superb and costly grounds, and with all its money, no one will wonder when I say that as to the animal collection itself, for the exhibition of which all this outlay has been made, no one can have any conception of its comprehensiveness or its extent unless he has studied it in its entirety. There are hundreds of forms represented from every department of the vertebrate kingdom. Some are extremely rare; others are upon the verge of extinction, and many are not to be found in any other zoölogical garden of the present day. This garden so far outranks every other institution of its kind in the world, that to dwell on that point would be to use valuable page-space to no practical end.

This Zoölogical Garden does more, however, than to simply place all these fine and rare animals on exhibition; for it either directly publishes—or indirectly assists in publishing—bulletins, books, circulars, and various other publications, magnificently illustrated, which are classics in their way, and which have had a tremendous influence in spreading zoölogical knowledge everywhere among the people of this country and abroad.

Still, it may safely be said that the work of the New York Zoölogical Park, and of the Society under whose control it is, has hardly more than just begun what it is so well fitted to achieve in the future. Fortunately, it enjoys the confidence of New York city and State, with all the wealth they can pour into its treasury. There are two lines of endeavor and research now open for this powerful organization to enter upon: one is to widen and energetically push all that leads to the protection and increase of the rapidly vanishing wild life of North America. It has already done something in this field, but it can do a great deal more which will rapidly show worthy results. It can only be through wise laws made along strictly scientific lines, and through the persistent efforts of such a society as I have attempted to describe here, that many of our fish, reptiles, batrachians, birds, and mammals can be saved from utter extermination in the comparatively near future. Remember the millions of wild pigeons we had not half a century ago—and now we have *none.* Other forms are being just as rapidly exterminated in this country by man as were those beautiful birds.

Another line of work to which the society and park should devote itself is the establishment of a thoroughly equipped prosectorial department, for the study of the morphology or anatomy of all the animals that die in the collections. This will require not only exhaustive prosectorial work, but the establishment of a fund to handsomely publish the results of such labors and researches. A great many of our animals of all classes are now passing rapidly away, and will soon be entirely extinct. If the structure of these is not studied and published in detail by the anatomists of the present time, the day will come when the morphologists of future generations will have good cause to say what they think of us and of our culpable neglect in such important fields. This entire department of science is now being sadly neglected in this country; and as I look back over the past forty years or more, I think of the correspondence I had with such workers in this field as the Parkers, Huxley, Forbes, Darwin, Sir Richard Owen, Cope, and many, many others of similar standing—men who never allowed a year to slip by without publishing their memoirs upon the comparative anatomy of some of the vertebrata and who powerfully increased our knowledge of such subjects. In these matters we have fallen far behind what was being accomplished during the latter half of the last century. Will it not be possible for the New York Zoölogical Society to revive the interest in these fields? With its unequaled facilities to prosecute such work, its unrivaled means, and its weighty influence, it most assuredly can do so.

"Pupinized" Telephone Lines

An Invention by Means of Which Telephone Conversations can be Carried on Over Long Distances

By Francis B. Crocker

Although the invention of the "Pupinized" telephone line was made fifteen years ago, and is often mentioned in papers relating to electrical matters, it has rarely, if ever, been described, except in very technical terms, although it is a matter of great general interest, as by this invention a problem of great practical importance is solved in an entirely scientific manner; in fact, it is a noteworthy example of obtaining great practical results from purely *a priori* reasoning. The problem was conceived, and largely worked out, by theoretical calculations before any experiments were made, even in the laboratory. In spite of its great importance and peculiar interest, the principles upon which this invention is founded and its real nature are often misunderstood, even by those otherwise well informed in electrical matters, and consequently the following description is presented in as popular language as the subject permits.

This invention was publicly described to the American Institute of Electrical Engineers by Professor Pupin in May, 1900, but was conceived and developed by him some time earlier. The principal object of the invention is to conserve the amplitude and form of the electrical waves corresponding to human speech when they are transmitted to considerable distances by conductors, especially underground and submarine cables. In this way the distance at which intelligible telephone conversation may be carried on is increased. The Pupin invention of "loaded lines" is often supposed to depend upon the neutralization of their electrostatic capacity by introducing inductance coils along such lines. This principle does apply to his pioneer work in electrical resonance, and in tuning circuits to make them responsive to a particular frequency of alternating current. But it does not, however, apply to "loaded" or "Pupinized" conductors. Indeed, the condition of resonance is avoided in the latter case, and a relatively large amount of inductance may be advantageous, especially for long lines, provided excessive resistance, hysteresis and eddy current losses are not introduced at the same time.

The simplest analogy to Pupin's invention is the fact that a projectile must have considerable mass in order to overcome the mechanical resistance of the air and travel a long distance. Similarly, a conductor must have electromagnetic mass, or inductance, in order that an electric impulse or wave may overcome the electrical resistance and travel a long distance. It is necessary in the case of the conductor to *distribute* the inductance along the path of the electric impulse or wave, hence the phenomenon is more closely analogous to that of a long cord stretched between supports, which must have distributed mass, that is to say, it must be a fairly heavy cord in order that mechanical vibration or waves may be propagated to a considerable distance along it. In the case of the electrical conductor, for example, a telephone line, it is not convenient to distribute the electromagnetic mass or inductance *uniformly*, so that it is introduced in the form of inductance coils placed at certain intervals throughout its length. This corresponds to the mechanical fact that a light cord with distributed weights attached to it is practically equivalent to a heavy cord. Pupin determined by calculation and by experiment that the distance between the coils, like the distance between the weights, must not exceed a prescribed amount in each particular case. That is to say, there must be at least a certain number of coils per wave length in order to approximate a uniformly *distributed* inductance, otherwise they may do more harm than good. Moreover, the shortest wave length must be considered. In telephony the highest frequency necessary to transmit articulate speech is about 1200 waves per second. This corresponds to the upper harmonics or overtones in some of the consonant sounds. Hence the wave length at this frequency is calculated for the given conductor, together with the loading coils, which have a certain total resistance, capacity and inductance that is assumed to be uniformly distributed. As demonstrated by Pupin, in a conductor having not less than eight or ten of his coils per wave length, this assumption is approximately correct. To arrive at these facts Pupin devised new mathematical methods, and solved the various problems in a most thorough and exact manner. He also made experimental tests upon artificial as well as actual telephone lines and underground cables which fully confirmed his theoretical investigations.

Pupin further showed how to design the coils for loading lines in order to obtain maximum inductance with minimum resistance, hysteresis and eddy current losses. In fact the practical success of his system requires that these losses be reduced to a minimum, and this was accomplished by ingenious and careful construction.

The Pupin "loaded line" permits higher voltage to be applied to it, whereby the electrical waves may be transmitted to a correspondingly greater distance. In the transmission of electric power it is sufficient to use 110 or 220 volts to supply motors locally. For long distances electrical pressures are raised to 100,000 volts, or even higher. In an analogous manner higher voltages applied to "Pupinized" lines increase the distance at which telephonic communication may be practically carried on. If the voltage were raised on an ordinary unloaded line the current would be proportionally increased and the losses would rise in even greater proportion. The losses would also be aggravated if resistance were introduced to limit the current. On the other hand, the introduction of inductance coils adds to the reactance of the line so that the current is not excessive even with a higher voltage. This reactance simply stores the energy momentarily and returns it, but does not itself increase the losses. There is a certain amount of loss in the resistance and iron cores of the coils, but this is relatively small compared with their reactance.

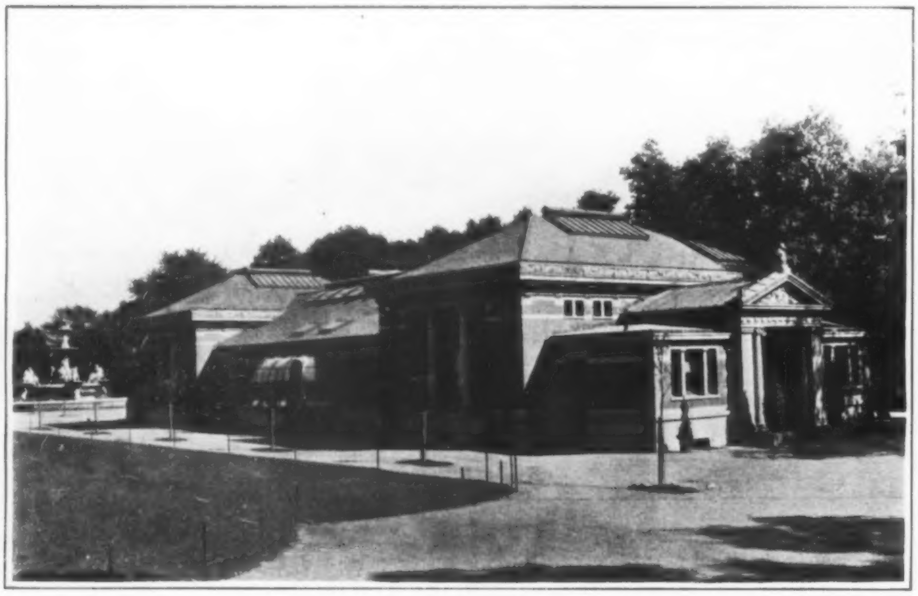
The industrial application of "Pupinized" lines has been remarkably successful and important. In the United States the American Telegraph and Telephone Company purchased Pupin's inventions in this field, and has "loaded" many thousands of miles of overhead and underground telephone cables with Pupin coils. In many cases the cost of the large conductors, as well as their excessive weight and bulk, would be practically prohibitive if it were not for the saving in the size of wire that is secured by Pupin's invention. This applies particularly to the very important telephone lines that have been laid underground between Washington, Philadelphia, New York and Boston in order to avoid the danger of interruption of overhead service by severe wind or sleet storms. There is a practical limit to the distance to which speech can be successfully transmitted by underground or submarine cables. For distances of fifty miles or more copper conductors of such large size would be required that their cost would be so high, and they would require so much expensive insulation to cover them, that the investment would become excessive. Moreover, the very object of using large conductors is to reduce their resistance and thereby make up for the relatively high electrostatic capacity of underground or submarine cables. At the same time these large conductors would have correspondingly greater electrostatic capacity, which calls for still lower resistance, and so on. In short, the remedy itself increases the trouble so that still more remedy is needed, which further adds to the difficulty, and the situation appears to be hopeless. Fortunately, the "Pupinized" underground or submarine cable may have conductors of moderate size, because their resistance does not have to be reduced to an extremely low value to make up for the high electrostatic capacity. The latter is practically inevitable when conductors are laid under ground or under water, due to the condenser effect between the conductor and the earth or water, as well as the sheathing usually applied to such cables. In accordance with the Pupin invention the electrostatic capacity is not neutralized but overwhelmed by introducing large inductance. Hence the above-described conflict of conditions is avoided.

Some Characteristic Views Zoological P

The Natural Scenery Surpasses Any Simila the Collections of Animals, Birds and R

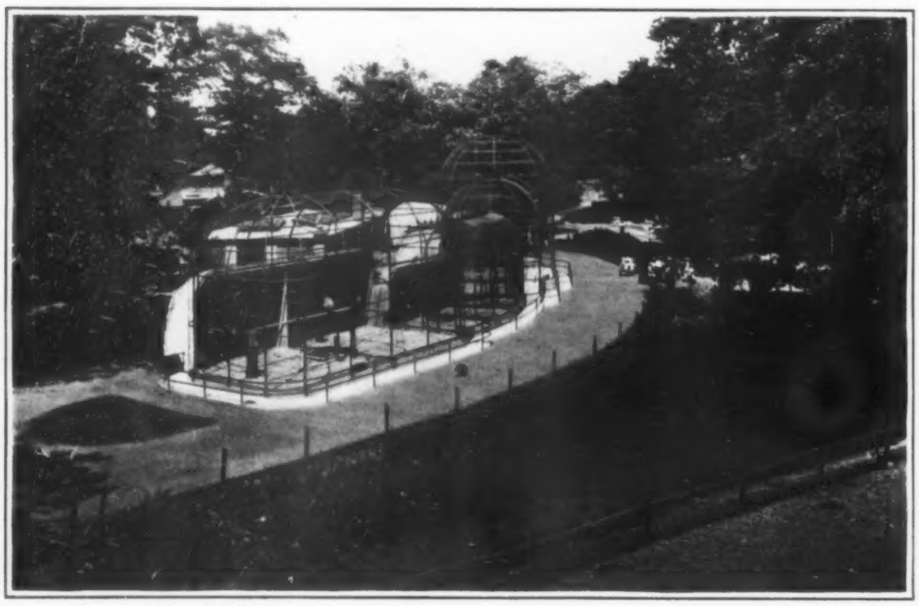
The concourse, Italian Garden, and north end of Baird Court.

This is the main entrance to the park and faces on the Pelham Parkway. At left is the Administration Building, while on the right is seen the large bird house.



The elegant quarters occupied by the Apes.

Ample space, light and air is provided to make the surroundings of these delicate animals as healthful as possible. Note the appropriate decorations.



Photographs by Courtesy of the N. Y. Zoological Society.

Eagles and Vultures aviary.

These large birds spend most of their time in the open air, and the roomy cages afford an opportunity for exercise.

Alaskan Brown Bear.

His genial countenance makes him a favorite with the public.

Pigmy Hippopotamus.

A sleek and comfortable looking little animal that attracts much attention.

Great flying cage.

This includes several large trees, and a water pool, making an ideal home for large aquatic fowl.

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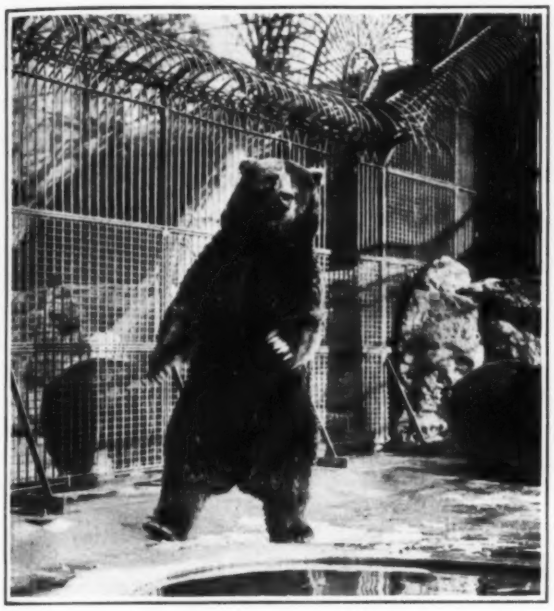
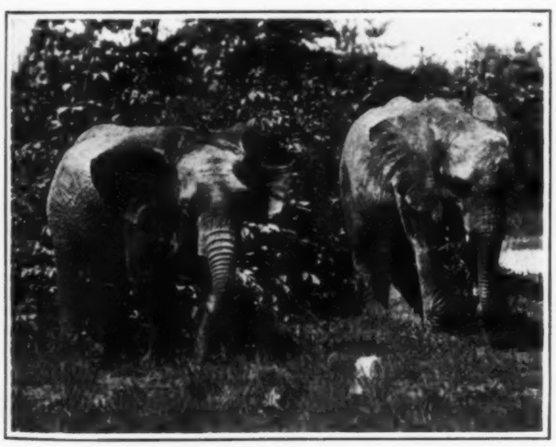


A refreshing dip in winter.

The bear dens are provided with large basins of fresh water, in which many bears delight to paddle.



African Elephants.

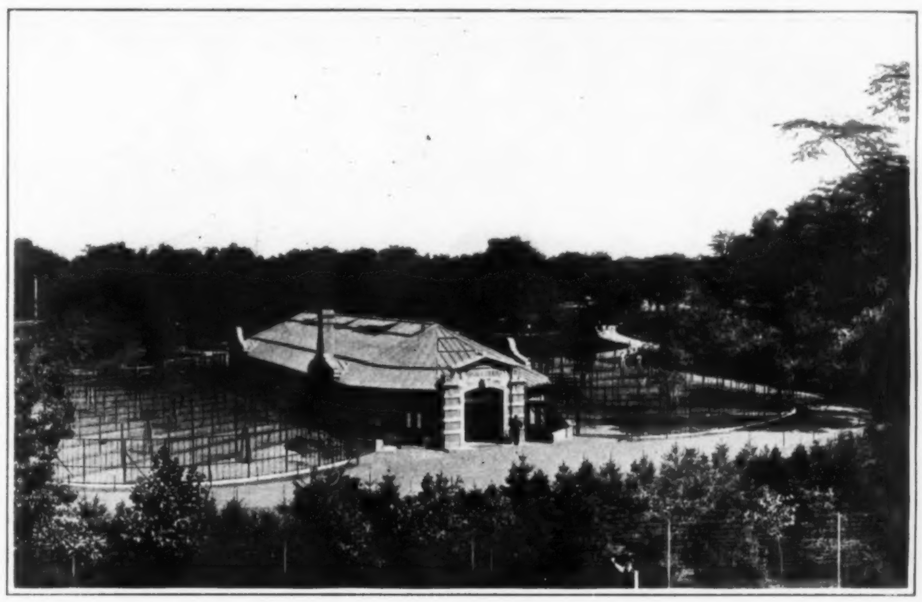
These great animals are here seen enjoying a ramble in the open.

Himalayan Tahr.

For the benefit of these, and similar active climbers, a rocky artificial hill is provided.

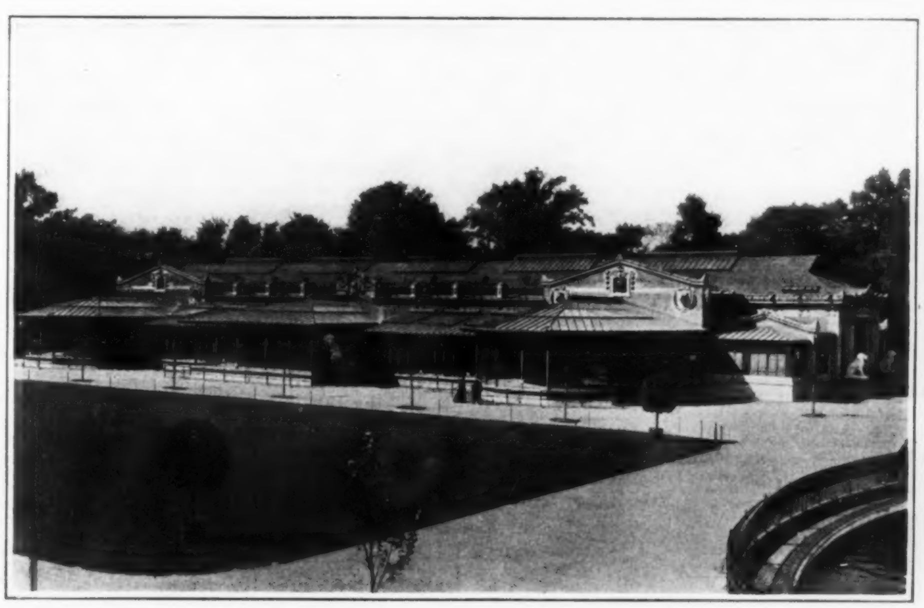
The Elephant House and paddocks, seen from the rear.

A spacious and beautiful building, with large open air exercising yards directly connected with the individual quarters within.



Small Deer house, showing the commodious cages.

Adjoining the house on both sides are the several exercising grounds for each species, surrounded by high iron fences.



The Lion house, showing open air promenades.

The lions and tigers are most comfortably housed, and adjoining each cage is an outdoor cage, sheltered from the weather.

Science for the Home*

Losses and Other Chemical Changes in Boiling Vegetables

By Katherine I. Williams, M.Sc., The University, Bristol

In a former article "On Cooked Food" in *Knowledge* (1912, xxxv.) the author gave some account of her investigations into the chemical composition of cooked fish and vegetable foods. It was fully explained that the main object of the investigations was to arrive at a clear idea of the value of food as served at table, and the results showed that many false ideas exist as to the proportion of nutrients contained; full details were given as to the preparation of the articles selected and the part played by water in the process of cooking, and attention was directed to the fact that the percentage of water is one of the most important parts of food analysis; we want to know how much solid food we really consume. In meat and fish there is a higher percentage of solid matter, and the whole of the flesh consists of nutrients, fat, protein, and mineral matter. Vegetables, on the other hand, besides these nutrients, contain starch inclosed in cell walls of fiber or, as it is also called, cellulose. The latter substance has a doubtful value from the food point of view as a nutrient. Inside this framework is found the starch; in the process of cooking the starch granules are gelatinized and break down the cell walls, as can be seen in a well-cooked potato. The effect of cooking as regards solid matter is interesting, since after this operation the nutrients in the case of fish and meat show a higher percentage, whereas with vegetables the reverse is the case with a few exceptions. Only the edible portion is here considered—that is, the portion of vegetables that can be eaten as food. A simple definition of food is the one to be found in Dr. R. Hutchinson's "Food and the Principles of Dietetics": . . . "anything which, when taken into the body, is capable of either repairing its waste or of furnishing it with material from which to produce heat or nervous and muscular work." The ordinary articles of diet are mixtures of various chemical substances, and among the most important of these are those containing nitrogen, examples of which are gluten in bread, legumin in pulses; but these are though different chemical substances and are classified under the general term protein. Non-nitrogenous is a term used for the carbohydrates, sugar, starch, also fats, such as butter. Another important group is called mineral matter (or ash), and here we have table-salt, also calcium specially found in asparagus and spinach, salts of iron also in spinach, peas and potatoes; finally, water, which forms a large part of even our most solid looking foods. In this article it is proposed mainly to deal with vegetable foods. As a rule, most vegetables are sold in a vague way as to price—by the bunch with carrots; spinach, however, is sold by the pound. Three samples were bought about the same time at twopence each per pound: (1) The waste was 4½ ounces; (2) solid 1 pound 3 ounces; waste, 3 ounces; (3) the weight of the paper included was ¼ of an ounce, 7 ounces were waste (stems and roots), leaving only 8¾ ounces for cooking purposes. The next question is how much refuse is there when bought? This consists of the skins of potatoes. Here, it may be remarked, care should be taken in the peeling of potatoes, as the layer next the skin is considerably richer in mineral matter and protein than any other part of the flesh; if this is wasted then the starch mainly forms the portion served at table. The best method to cook this vegetable is in the skin. With green peas the pods are often looked on as waste; they form 45 per cent of the vegetable as sold, but can be used for soup provided some peas are added. A fact not generally known is that the pods are chopped up, boiled or steamed till the mass is soft; it is then crushed and passed through a sieve to separate the fiber from the edible portion; the latter is evaporated down, mixed with sugar, and sold as a kind of marmalade, or mixed with currants, gooseberries, or banana pulp and made into jam.

Two examples are given of the refuse in fish as sold, but it is often cleaned before leaving the shop, which is not usually the case with vegetables.

Before preparing the sample for cooking it was weighed, and then the refuse was weighed and percentage calculated; so now the remaining vegetable is weighed before and after the process of cooking, to determine the increase or decrease which is due to the loss or absorption of water. All waste is removed, such as the hard part of the stems of asparagus, bones and head of fish, shells of eggs. With one class of foods, the cereals, there is no refuse or waste; all is consumed as food.

All vegetables were simply boiled in water as supplied by the Bristol Water Company; this water is hard, due to the presence of calcium carbonate, but is otherwise excellent.

* *The Chemical News.*

It will be seen some foods contain the two kinds of refuse, one the portion removed before cooking, the outer leaves of vegetables, the other the stems, bones of fish, etc., left after serving at table, and the asparagus is one example; this sample cost 9½d. per pound, only 31¼ per cent was fit for cooking, and of this 31¼ when cooked and served at table only 66 per cent could be eaten, making this vegetable an expensive article. A great deal of information has been published in America by the Department of Agriculture in Bulletins which are freely distributed in that country and can be bought by anyone for a few pence each; one in especial is valuable, No. 28 (Office of Experiment Stations), prepared by Prof. Atwater and A. P. Bryant, entitled "The Chemical Composition of American Food Materials;" it contains details of the analyses of 4,060 American articles and commodities used for human food in that country, but in most cases they are uncooked.

We must now pass on to the main question—what are the principal changes that take place in the process of cooking? The first point is the change in the percentage of water; we could not live on dry foods—that is, foods that contained no water; on the other hand, it is clear a high percentage results in a bulky food.

REFUSE FOR COOKING.
(In 100 parts.)

Food.	Refuse.
Endive	52
Green peas	45
Parsnips	7½
Green artichokes	72½
John Dory	21½
Cucumber	15
Borecole	38
Carrots	23
Celeriac	7
Vegetable marrow	18
Leeks	75
Gurnet	9

During the process of cooking meat and fish we have a decrease in weight. Prof. Grindley, of Illinois, has done a good deal of work on the subject of losses in the cooking of meat and the influence of cooking upon the nutritive value of meats. He found, besides losing water, some of the fat, protein, and mineral matters are dissolved out. He examined the extracts from boiling lean beef, and found as the average of 91 samples the loss of mineral matter was 44½ per cent of the total amount present, of fat 12 per cent, and of protein 7¼ per cent. The same is true of fish. While nutrients are lost in the process, as is proved by the examination of the liquid after the meat is removed. a higher percentage of nutrients is found in the cooked condition and a lower percentage of water. With vegetable food the reverse is true; as commonly cooked almost all vegetables show an increase in the percentage of water and a lower percentage of nutrients. The question arises: Is this waste necessary? That is, can it be prevented? In Bulletin 43, Office American Experiment Stations, Prof. Snyder describes the loss in boiling potatoes, cabbage, and carrots. He found with potatoes the greatest loss was when they were peeled and soaked in cold water before boiling, amounting to one quarter of the total protein present—"in a bushel of potatoes the loss would be equivalent to a pound of sirloin steak." Less loss is sustained if the peeled vegetable is at once plunged into boiling water, as then the proteins are coagulated on the surface and make the inner juices less liable to loss. When the potatoes are cooked in their skins the best results are obtained. The loss of mineral matter by the first method is as high as 38 per cent. As generally cooked an excess of water has to be drained off; this is often thrown away. Prof. Snyder remarks with carrots a good deal depends upon the size of the pieces into which they are cut for cooking, the loss being greatest with small pieces. Often about 1 pound of the sugar alone per bushel is removed, losing one quarter of the total nutrients. To get the best food value the pieces should be large and the boiling rapid, and as little water as possible should be used.

REFUSE AS SERVED AT TABLE.
(In 100 parts.)

Name.	Refuse.
Asparagus	34
New potatoes	2¾
Green artichokes	69
John Dory	21
Herrings	12
Haddock	35

Cabbage in the raw condition only contains 7½ pounds of solid in 100 pounds, and of this 2½ to 3 pounds are lost in cooking. It is quite clear that such losses ought to be taken into account in drawing up dietaries. Further, such methods of cooking produce unpalatable dishes. Of losses found by the author in the course of her investigations spinach may be mentioned. In this case there are only 10 pounds of solid in 100 pounds of the vegetable; after cooking the loss is 2¼ pounds, about one fourth of the total solid. Celeriac 9½ pounds of solid in 100 pounds of raw, and the average of three samples shows 4½ pounds are lost. Curly greens or borecole 100 pounds contain only 10⅝ pounds solid, and of this 5¼ pounds are lost, in both cases about one half of the solids. Turnips only contain about 9 pounds of solid per 100 pounds, and here the loss is nearly 4 pounds. In cooking lettuce we find 1 pound lost of the 4 pounds (or one fourth) solids in 100 pounds of the raw vegetable. With the large variety of asparagus matters are rather better, as of the 8 pounds solid only ½ pound is lost per 100 pounds uncooked.

This, then, is the result of ordinary methods of cooking. Presumably the idea is that since vegetables are cheap it does not matter if nearly half their nutrients are thrown down the kitchen sink. Sir Henry Thompson, many years ago, drew attention to this waste in "Food and Feeding." The remedy he and others suggest is the use of the liquid in which vegetables are boiled for the foundation of soup, like the French peasant's "*pot-au-feu.*" "To the pot of the peasant, who wastes nothing whatever, all things are welcome, and every atom of nutritive material—solid or liquid—goes into it, to which are always added herbs and vegetables, together with the liquor in which any of the latter may chance to have been boiled. Sometimes it is a *pot maigre*, no meat of any kind having been procurable, and very good vegetable soups, moreover, are educible therefrom."

Another method of cooking is coming to the front, and is called the "Conservative." Using this, vegetables are no longer merely washed-out stuff with all the goodness boiled and drained away and then pressed in a cloth. When the new method is employed as little water as possible is used, and that is absorbed or evaporates away. No draining or pressing is necessary, consequently there is no waste.

I have carried out some experiments recently to test the value of this process and found very satisfactory results. The first samples used were carrots and parsnips. In 1 pound about one twelfth of the total solid was lost, while more recently, with still more care in cooking green peas, celeriac, new potatoes, salsify, and turnips, the waste has been *nil*; all the water has been absorbed and the cooked vegetable has retained all its nutrients.

This series of vegetables was cooked in a Welbank's boilerette. These cookers are very simple in construction, and are practically a type of double saucepan. A certain amount of water is placed between the two vessels. The boilerette is then placed over the heating apparatus, and when steam comes through the valve the prepared vegetable can be put in the machine with half a teacupful of water. Some vegetables are better done when they are put into the basket which fits into the apparatus. Potatoes, for example, take rather longer cooking, but the process goes on by itself and does not need constant attention. Some cooks have used an ordinary saucepan for cooking spinach, with only the addition of just enough water to be absorbed, and in this method there was no loss of solids.

The two methods can be compared, and it is seen that to get the full value for the money spent the "Conservative" is the most economical. To return to the losses in cooking, it is interesting to know exactly which of the nutrients are lost and how the loss is ascertained. As soon as the process of cooking is finished the excess of water is drained off into an evaporating dish whose weight is known; heat is applied, and when only the solid is left the dish is again weighed and the percentage and weight of the loss is calculated. The solid is reduced to powder and analyzed. The result of analysis shows none of the fiber, fat, or starch is lost, but carbohydrates in the form of sugar are, as has been said in the case of carrots, and is also true with beetroots. The most important losses are protein and mineral matter; with potatoes, protein 25 per cent, of the total mineral matter 38; carrots, loss of protein 6½ per cent. Here the carbohydrates being mainly sugar the loss is 25 per cent of mineral matters, 37 of the total present in each case.

The percentage per 1 pound of the following vegetables

shows the loss in the total solids: Celeriac, loss one half; of this, 7 per cent was mineral matter and 54 per cent protein; curly greens, two fifths of the total solid, 15¾ of this is mineral matter, 41 per cent protein. Chicory, one fifth of solid lost; of this 42½ per cent protein, 12 per cent ash. Butter-beans lost one tenth of the solids, of which 28¼ per cent was protein, 5½ per cent ash. Endive, total loss about one fourth of the solid; of this, 29½ per cent was protein, 18¾ per cent ash. These mineral matters are needed by the human body as tissue formers, and can supply the potassium, calcium, iron, phosphorus, and sulphur in an ordinary diet; calcium and phosphorus in milk, the latter also in carrots, turnips, potatoes, various varieties of beans and peas. Iron among other sources is found in the yolks of eggs, oatmeal, potatoes, spinach, and apples. Prof. Sherman, of the University of Columbia, in Bulletin 185, Office Experiment Stations, gives details as to the value of iron in food and the needs of the human body. He also goes into the question of calcium, magnesium, and phorphorus. In Bulletin 227 he, with the assistance of others, gives full details of their dietary studies, the desire being to solve the question, how much of these elements are needed in the human diet?

The next important question is as to the percentage of water. When cooked in an excess of water which is drained off, the cooked article contains more water than the uncooked. Cooked the conservative way in the boilerette the percentage sometimes varies, in the other method a lower percentage in the cooked vegetable is quite an exception.—

THE PERCENTAGE OF WATER IN THE RAW AND COOKED CONDITIONS.

Name.	Raw.	Cooked.	Cooked in Boilerette.
Scarlet runners	93	94	..
Beetroot	82	83	..
Endive	91	95	..
Parsnips	76	81	79
Green peas	70	87	73
Celeriac	91	94	89
Jerusalem artichokes	80	92	79
New potatoes	81	..	83
Salsify	82½	84	80

Two vegetables on this list are not as well known as they ought to be, the names are even unknown by greengrocers doing a fairly good business; salsify is one of them. The roots can be left in the ground until late in the season, and it comes into use as a variety in the winter. It is often called the oyster plant, because the flavor suggests that of oysters. The other vegetable is celeriac, which is also known as "knot celery" and "turnip rooted celery;" the roots only are eaten. It also comes into the market during the winter. Its flavor is something like celery.

In another class of vegetable foods the change in the percentage of water is still more marked; that is, the pulses. In dealing with these foods one of the most important factors to consider is the amount of protein present. We often see the statement that the pulses are rich in this nutrient, and for this reason they are called "poor man's beef." This is true only in the uncooked condition, but not as we eat them. This idea arises from the incorrect method of describing the results of analysis. In most tables the percentage of water is left out, and only those of fat, fiber, protein and carbohydrates are given, thus making these percentages appear higher than they really are; also the comparison is between meat and pulses in the uncooked state. Here we find for protein, beef 22, veal 20, mutton 20, lentils 22, peas (dried) 21. Now, in the process of cooking, meat has lost water; therefore, the percentages of fat and protein are higher in the cooked condition, while with the pulses the reverse is the case, so that all the percentages of the nutrients are lower: Beef (boiled), 34; veal (roasted), 29; lentils, 9; peas, 9; that is, the percentage of protein in the natural moist condition as served at table.

PERCENTAGE OF WATER.

Name.	Uncooked.	Cooked.
Beef	71	57
Veal	71½	58
Mutton	67	51
Lentils	12	66
Peas, dried	14	62

With cereals, such as oatmeal, we have no loss of nutrients; all the water used in cooking is absorbed. Starting with 10 pounds of each of the following articles we find provost barley and oats 60, frame-food 156⅓, plasmon arrowroot 113, rice (prepared by a conservative method) 36 pounds.

These, then, are the chief changes in cooking vegetable foods, and it cannot be satisfactory that so much of the valuable nutrients should be lost by bad methods of preparation. It may be said vegetables are cheap, but the great object of cooking is to make food attractive and wholesome, and it is the salts which give the flavor. It is a pity the subject of the scientific value of food is not studied in this country in the same way that it is in America. Much can be learnt from the publications of the Department of Agriculture in that country.

The Use of Clay Products in Domestic Building Construction*

As yet the field of permanent building materials has hardly been touched. On account of the increased cost of using such materials in domestic architecture, many people have been influenced to use frame or wood construction instead. But the supply of lumber is gradually decreasing and the people are having to turn to clay and cement products instead. The ever present fire risk in frame construction has done much to influence public sentiment toward more permanent structures. Before the use of permanent building materials will become universal it will be necessary to develop a whole group of contractors who understand structural problems and how to estimate intelligently. Up to the present time the use of brick and tile in domestic architecture has been very limited, inasmuch as the increase in cost has put its use out of the reach of the man of moderate means.

Very artistic effects can be obtained by the use of brick and tile. In fact, very few people have any conception of the number of ways in which these materials can be combined. For example, we will assume the design of a small brick residence. We will consider for the time being the treatment of the exterior surfaces. The first problem that presents itself is the color scheme. If we assume that we are to use a light colored brick it would be necessary to decide upon the color of the mortar to be used and the width of the joints. There is nothing which adds or detracts more from the beauty of a brick wall than to have no contrast between the brick and mortar and not to have variety of texture in the brick surfaces. Texture in brick surfaces can be obtained by using light and dark shades of the same brick, for example, introducing here and there brick which have been burned somewhat darker than others. Another way is by choosing a mortar joint which will give a shadow, for example, some brick require a flush or smooth joint to bring out the character, while others look better with raked or sunken joints. The smooth surface brick generally look the best with deep cut joints, while wire cut brick or matt surfaced brick such as that made at Boone, Iowa, require smooth joints in which the mortar comes out flush with the face of the brick.

Another way in which artistic effects can be obtained is by varying the color of the mortar. For example, a dark red wire cut brick will generally look the best when white mortar is used. This will tend to add contrast to the wall and hence eliminate a monotonous color scheme.

If dark mortar is used this feature requires considerable skill in treatment and can only be satisfactorily tried by laying up a small panel of brick work and experimenting upon color effects, etc. By varying the width of mortar joints interest can be gained. In fact, many times the beauty of a particular kind of brick is entirely lost by making the joints too narrow. Sometimes a joint as wide as ¾ inch will add just the right note to the appearance of the wall. Many brick masons will say that such wide joints are not satisfactory, but such a condition is due generally to ignorance on their part. Laying up brick with the wide mortar joints is somewhat more expensive because it takes much longer and also requires more mortar, but generally a matter of a few dollars invested in such a case will more than pay for the expenditure. It is so much more satisfactory to have a good looking wall both from an artistic as well as from a structural standpoint. Again, different varieties of brick combined, make interesting wall treatments. For example, it is possible to use a dark red brick with a light buff brick, and when worked in panels and patterns gives a very artistic effect. Care must be taken however not to violate color harmony nor to sacrifice structural features by introducing too much ornamental brick work.

Hollow tile block offers many opportunities for use in building construction. To-day a large percentage of foundations for small residences are made with blocks laid in mortar. This material offers many opportunities and its greatest advantage lies in the air chambers within the blocks. Objection however has been made that unless the walls are properly laid up, the interior of the house is cold, due to the leakage of heat. I believe that it is a mistake to apply the coating of plaster to the tile directly, because of condensation of moisture on the surfaces of the walls, causing serious results to the interior decoration of the surfaces. The wall should be stripped and then lathed and plastered as in frame construction. The argument is made, however, that such a condition does not take place, but the author has seen many fine examples of condensation and can not recommend such a procedure. Hollow tile as a building material has many merits. For example, it is easily and rapidly laid up and is comparatively inexpensive in cost, and, exclusive of brick and concrete, is the best surface for the application of cement stucco. This is due to the fact that the coefficients of expansion of the two materials are nearly equal, and hence the elimination of cracks and surface defects.

Manufacturers of tile and brick are beginning to realize the necessity for making a product which does not require an exterior coating of cement. Very artistic effects can be gotten by using hard burned vitrified block for facing, just the same as with hard burned or wire cut brick. In fact, in some of the Eastern States many residences have been made of this material and very satisfactory results obtained. At first one is not accustomed to the large size of the blocks in comparison with brick sizes, but the time is coming when such materials will be more widely used than ever before. In fact, to-day in rural communities the agriculturist is building his barns of vitrified tile and getting excellent results. There is no reason why he should not build his house in the same manner. Variety in surface treatment can be obtained in exactly the same manner as with face brick. Joints can be pointed with colored mortar and varied in width if desired. To be sure, our carpenter friends do not approve of such materials because they decrease the amount of work for members of their trade, and so to-day, in getting estimates upon buildings of permanent construction, it is a very difficult problem to get satisfactory figures. The primary reason is that the mechanics are not familiar enough with the use of such products and, as of old, do not like to take a chance on such construction without being highly paid for the same. There is no reason why a house of tile construction can not be built for approximately the same cost as one of frame, and, in fact, the time is coming when such will be the case.

One of the best evidences of the necessity for permanent building construction is the enormous fire loss each year. In fact, there are certain fire prevention and fire protection organizations in this country which are doing everything possible to educate the public along these lines and one of the greatest steps that can be taken is to protect the isolated home against destruction.

For evidence of permanent building construction one has only to turn to European countries. There we find that the lowly peasant lives in the same house which was occupied by his ancestors many generations before, and to-day these houses are just as good as when originally built. The European has had to look to economy of construction in every form and he has been awake to the fact that it is better to build permanently than to build temporarily and have to repair and replace the same within a period of a few years. This condition is fostered by the scarcity of lumber and hence its increased cost.

With the increased manufacture of brick and clay products the American citizen has every opportunity to build better homes at less cost and greater permanence than ever before. It is to be hoped that more people will take advantage of fire resisting construction and use the same in every building. By so doing, the cities and towns of this State, and every other State, will become more beautiful and artistic. The structures will be more permanent and will be subjected to a minimum risk of destruction by the elements.

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Highly Phosphorescent Calcium Sulphide

A RECENT issue of the *Comptes Rendus* contains an account by M. P. Breteau of his experiments on the production of highly phosphorescent calcium sulphide. One of the most active was made by heating precipitated chalk with thirty per cent of its weight of powdered stick sulphur in a closed crucible for an hour, then impregnating the cold product with a trace of bismuth (0.0001 per cent in the form of an alcoholic solution of basic bismuth nitrate), again heating the mixture for two hours longer at a dull-red heat, and then allowing the still closed crucible to cool slowly in the furnace. Products exhibiting less phosphorescence were made by impregnating the calcium sulphide with tungstein, molybdenum, or vanadium. The presence of sodium carbonate, or chloride, in the original mixture had either no effect or an injurious one on the phosphorescence, and impurities in these salts may have been the cause of the phosphorescence which Verneuil observed with such fused mixtures.

The Development of the Military Aeroplane*

A Discussion of the Question of Size

By F. W. Lanchester

THE investigation forming the subject of the present article was embarked upon by the writer with a view to determining so far as is possible, as a generalization, the most appropriate size or weight of aeroplane to be employed for any given military duty.

There has been for some time past a belief current with the general public, and among engineers who have not studied the problem of flight closely, that future developments are to be expected in the direction of a great increase in the individual size and power of the aeroplane. This belief has been reflected in the work of several designers (notably in Russia), as evidenced by the construction of machines weighing 3 or 4 tons.

The writer has never believed in the probability of early developments in this direction; in 1908, in the second volume of his "Aerial Flight" (page 153), he gave the probable range of size of the flying machine (of the then "visible" future) as from ½ ton to 2 tons weight. This estimate was based on various considerations, both as concerning stability and as related to the aerodynamic and engineering outlook; the latter founded on data given in the earlier volume, where the possibilities of construction had been forecasted with considerable accuracy. Thus the weight of the power installation (without fuel) of the aeroplane is to-day commonly about 25 per cent of the gross weight. This is as given in 1907, on page 333 of *Aerial Flight*, vol. I. The gasoline capacity of the standard military machine of to-day is approximately 10 per cent of the gross weight. This is the basis given on page 331 of the volume aforesaid, and is that on which the final column in Table XV is founded. Again, on page 243 *et seq* (§ 170), and on page 285 *et seq* (§ 194), the question of aerofoil weight is discussed, and in an example given for illustration the wing weight is 22½ per cent of the gross weight. In one of the most popular of the British machines of to-day this figure is almost exactly that realized.

Although in the passages above cited the question of aerofoil weight was discussed, as affecting the conditions of least expenditure of work, it was not specifically discussed as a factor in determining the best size of machine; in other words, the relations between the "military load" specified for any given duty and the gross weight of machine best employed, and the gasoline capacity available. The establishing of this relation is the object of the present article.

The whole problem is one of considerable complexity, and in generalizing for practical purposes it is not necessary to take account of every factor which, strictly speaking, enters into the problem.

In dealing with the problem in its simplest form we may suppose the velocity of the design in contemplation to be an invariable. This assumption cannot be far from the truth, insomuch that the highest admissible minimum flight speed is determined for military aeronautics by the landing grounds available under military conditions, and the maximum flight speed is determined by the horse-power installation which can be employed. Thus, if we take the flight speed as constant, it is fair to allot a certain definite proportion of the gross weight of the machine (the same in every case) to the power installation. In the present investigation this is taken at 25 per cent of the total gross weight, as in accordance with the writer's forecast and with present-day general practice. The fixing of this proportion is virtually tantamount to asserting that the gasoline motor can be designed to a given *horse-power/weight* factor, whether it be large or small, and this may be justified on the grounds that where a big power installation is employed, it is not unusual to duplicate the power unit rather than build a special larger type of engine; it is further justified by the fact that so long as a given size of cylinder is adhered to, the best which can be done in the way of weight reduction, with a given type of engine, is practically constant whatever be the power and size of the installation. Thus the lower powered engine will have a smaller number of cylinders, and the higher powered a greater number. If we consider ultimately the possibilities of design, it is improbable that the designer will be able to obtain a better horse-power/weight factor for an engine of say 200 horse-power than he can for one of 100 horse-power, and, as above remarked, the horse-power/weight factor can only be kept down in the big engine by employing a greater multiplicity of cylinders than in the smaller one, a course which beyond a certain point is open to objection.

* *Engineering.*

The next point on which a convention may be made concerns the weight of the fuselage and alighting chassis; that is to say, the whole of the structural parts of the machine *excepting* the aerofoil itself, with tail and rudder, members whose weight varies in like ratio. These components again commonly total up to about 25 per cent of the total gross weight, and, generally speaking, it is not possible to obtain any relief in this part of the dead weight of a machine by making it bigger. There are, it is true, certain parts which can be relatively less weighty, such as those which relate to the pilot and seating accommodations, control mechanism, and so forth; but the alighting gear will have to be disproportionately heavier on the big machine than on the small machine, on the same principle, and for the same reason, that an elephant's legs have to be of a relatively greater diameter than those of a horse, or, going to an extreme, than those of a stork or flamingo. On the other hand, the weight of the fuselage itself may not necessarily require to be increased quite in the same ratio as the gross weight, though it is by no means clear that a serious saving can be made. It is not fair to assume, for example, that for a given military duty or purpose the same fuselage can be employed with bigger flight organs and heavier motor, etc., since the length of the fuselage has to be related in some degree of proportion to the flight organs themselves and to the general size of the machine; also the strength and scantlings of the fuselage have to be increased in proportion to the bending moments, etc., which may be taken as roughly proportional to the increase in weight, even if the size be not increased. The writer feels that it would be an optimistic designer indeed who would expect to save relative weight on the percentage of total on the combined fuselage and alighting chassis of the large aeroplane as compared with the small. He believes that in taking these combined weights as a constant proportion of the whole he is acting favorably, rather than otherwise, to the large machine. It would thus appear that, roughly speaking, half of the gross weight of an aeroplane is made up of its main structure and power installation with their associated parts, and the remaining half of the gross weight is available for the military load, the aerofoil weight, and the carrying of gasoline.

The next step is to formulate the law by which the aerofoil weight is related to the gross weight of the machine, that is to say, related to the total weight carried. The simplest basis is to assume an aerofoil of a geometrically constant form—that is to say, whatever type of aerofoil is selected, whether biplane or monoplane; and whatever method of construction is employed—that is to say, whether wood spars or steel tubular spars, or what not—the selected type of structure and method of construction is taken as applying to all possible designs under consideration, large or small.

Now, on the basis of constant velocity, the span must vary as the square root of the gross weight; this is a matter of aerodynamics. The aerofoil weight will vary as the cube of the span, for the bending moments at any point in the wing length or at any point in the wing structure vary as the weight multiplied by the span—that is to say, as the span cubed; and since with similarity of design the linear dimensions will vary as the span, the strengths of the members must vary as the span squared: in other words, the scantlings will be proportional and the aerofoil structures will be geometrically similar in every respect. Thus the aerofoil weight will vary as the span cubed—that is to say, if the gross weight $= W$,

Aerofoil weight varies as $W^{\frac{3}{2}}$

The above is the assumption which will be taken first, as it forms a simple introduction to the more complete investigation which follows:

In Fig. 1 a diagram is given representing the wing structure or aerofoil weight—the curve $c\,C\,c_1$, the ordinates of which (axis of y) represent aerofoil weight, and abscissæ (axis of x) gross weight of the machine. In accordance with the foregoing, the equation to this curve is

$$y = a\,x^{\frac{3}{2}}$$

where a is a constant.

Let the axis of y be extended to O_1 so that $O\,O_1$ represents to scale the constant load which it is required to carry; in other words, the *military load*, comprising pilot, observer, or gunner (if any), with machine-gun or other weapon, ammunition, bombs, etc. Then a line $O_1\,1$ drawn at 45 degrees will represent, by its ordinates, the gross weight, and lines $O_1\,2$ and $O_1\,3$ will represent, by the ordinates cut off, the proportion of the total (25 per cent in each case) assigned to the *fuselage*, etc., and to the power installation respectively.

The portion of the ordinate cut off by the line $O_1\,3$ and the graph $c\,C\,c_1$, and lying between these limits, will then represent to scale the weight disposable as gasoline, and the proportion as part of the gross weight is given by the per cent scale to the right hand of the figure, as determined by the lines directed to the origin O_1.

Now, the gross weight corresponding to greatest relative gasoline capacity is defined by the point C at which a tangent drawn to the curve passes through the origin O_1.

Let W = gross weight.
w = aerofoil weight.
M = (constant) military load.

$$\frac{dw}{dW} = \frac{w + M}{W} \qquad (1)$$

But

$$w = W^{\frac{3}{2}}$$

or

$$\frac{dw}{dW} = \frac{3w}{2W}$$

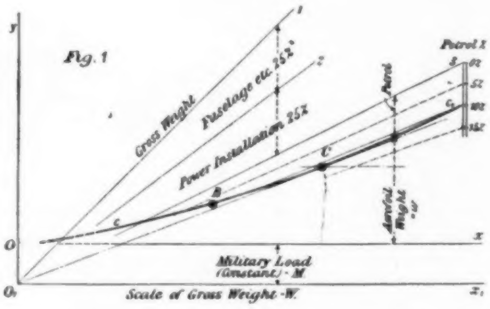
or by (1):

$$\frac{3w}{2W} = \frac{w + M}{W}$$

or

$$w = 2M$$

That is to say, the relative gasoline capacity is greatest *when the aerofoil weight is double the military load.* This is as given in Fig. 1 by the point C.



As in all ordinary cases of a maximum or minimum, there are always other considerations tending to make the practical engineering solution differ from that given by the mathematical solution, and the compromise to be adopted in any case will depend upon the relative importance of the various conflicting factors. On referring to the figure, it will be seen that anywhere in the region of the point C over a range of about 20 per cent, or 25 per cent of the gross load, plus or minus, the percentage of gasoline does not sensibly, or at least seriously, vary. Hence, since the duty performed is constant, it will be most uneconomical to employ a machine of gross weight as given by an ordinate at C (nearly eight times the military load), when a gross weight say five times the military load (as at point B) would do the same work with about 80 per cent of the maximum gasoline percentage, and therefore 80 per cent of the range of flight.

In some particular cases where the utmost range of flight is imperative it might be expedient to design to a somewhat higher gross weight, say six times the military load; but for the example taken in no case would anything much above this be warranted.

It is thus manifest that for the purposes of the aeronautical engineer or designer the mathematical solution for maximum relative gasoline capacity does not give sufficient information, or adequately act as a guide in settling the specification of a design for any stated duty. A graphic lay-out of the type given in Fig. 1 is necessary; it is just as important to know the extent of the sacrifice in gasoline capacity for values of W (the gross load), other than that of maximum, as to know the particular condition defining the maximum itself. Hence in the further development of the subject in the present article the mathematical treatment has been discarded in favor of a purely graphic representation.

The basis on which the graph $c\,C\,c_1$, Fig. 1, is founded is only roughly approximate, since the aerofoil weight w included as part of the total may be considered as in

reality borne locally, and as not giving rise to serious or sensible stresses within the aerofoil structure, so that the structural stresses within the aerofoil are due to the weight W minus the aerofoil weight. This introduces some complication, but the departure is easily dealt with by graphic construction. Thus, in Fig. 2, the corrected curve of aerofoil weight is obtained graphically from the curve given in Fig. 1 to comply with the new condition. The curve is first laid out as before, and increments of W are added equal to w at any selected points on the curve, the corrected curve being drawn through the points so obtained. The equation to the new curve is thus:

$$w = c(W-w)^{\frac{3}{2}}$$

In Fig. 3 an example is given with a curve (derived as in Fig. 2) representing a machine designed for a military load of 500 pounds and with an aerofoil weight which would correspond in practice (according to the ordinary current methods of construction) to a factor of safety of about 5 or 6, as recommended by the Advisory Committee for Aeronautics. Here it will be seen that the ultimate *maximum percentage of gross weight* which can be carried as gasoline represents about 18½ per cent, and the gross weight of machine corresponding to this is in the region of 6,000 pounds. Clearly from the diagram it would be absurd to build a machine 6,000 pounds in weight, for its actual consumption of gasoline would be twice as great as that of a machine 3,000 pounds gross for the same duty, and the latter machine would have over 80 per cent of the flight range of the other, as indicated by the relative gasoline capacity. According to the rule given in the simpler case, Fig. 1, the aerofoil weight = twice the military load, shown by point A in Fig. 3, the appropriate gross weight is about 4,700 pounds, and the loss of flight range as due to the lowered percentage of gasoline is a matter of about 2 or 3 per cent—that is to say, the gasoline capacity will be about 18 per cent of the gross load instead of about 18½. It is evident that no sane designer would go beyond this point.

If for ordinary military flying we take it that 85 per cent of the maximum relative gasoline capacity is good enough, then, for the machine in question, the gross weight will be about 2,800 pounds, as shown by point B, and the aerofoil weight will be approximately equal to the military load. The actual consumption of gasoline of such a machine for a given military duty will be less than half of that which would be necessary if the actual minimum (corresponding to 6,000 pounds gross weight) were adopted. From the diagram in question it is clear that for the military load of 500 pounds a machine between 1 and 2 tons weight is appropriate. 1 ton being sufficient where a 10 per cent gasoline capacity is all that is required, as in local reconnaissance or for defensive purposes, and 2 tons in the case of a machine for raiding or other purposes in which great range or radius of action is important. Thus the machine of 1 ton would have a flight range of between 300 and 400 miles, and that of 2 tons about 700 miles; beyond this no material advantage can be obtained.

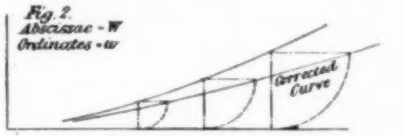
As examples of two extreme values of military load Figs. 4 and 5 are given, the construction being identical to that shown in Fig. 3. In Fig. 4 the military load has been assumed as 150 pounds, a lower limit representing a pilot only, with virtually no equipment. In Fig. 5, as an extreme case, the military load has been taken as 2,000 pounds, this being a load beyond anything ordinarily required and would correspond to the carrying of a Whitehead torpedo, or it would represent a capacity of three bombs of 6 hundredweight each.

In both Figs. 4 and 5, as in Fig. 3, the factor of safety or dynamic load-factor of the aerofoil has been taken in accordance with the recommendations of the Advisory Committee for Aeronautics as about 5 or 6, and the weights are further based on present-day practice in biplane construction in which this factor of safety is embodied.

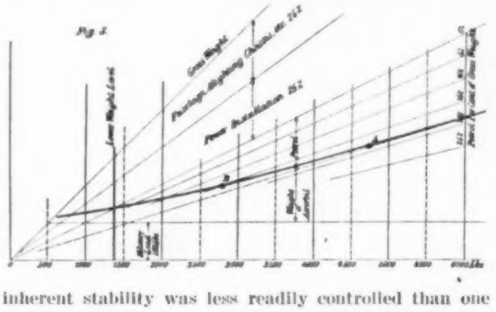
These figures speak for themselves; it is clear that if Figs. 3 and 4 be taken to represent the limits of ordinary military flying, the writer's 1908 estimate of the probably useful range of weight of aeroplanes is fully justified. The carrying of a load of over 2,000 pounds (as in Fig. 5) may fairly be regarded as duty of an abnormal kind, involving a special machine outside the ordinary run of experience. Such machines would form but a very small portion numerically of the total of the aeronautical forces.

It is now time to consider the extent to which the assumption of a constant flight velocity is, in fact, justified, and to point out the effect of the foregoing conclusions on departures from this condition. First, it may be remarked that the lower limit of flight velocity—that is to say, the lower limit for which it is possible to design as the normal speed of flight—is determined by questions of stability and by questions meteorological and military. The superior limit to which it is possible to design is, on the other hand, related to the horse-power required, and by the area of the flight grounds, which, under practical military conditions, can be made available.

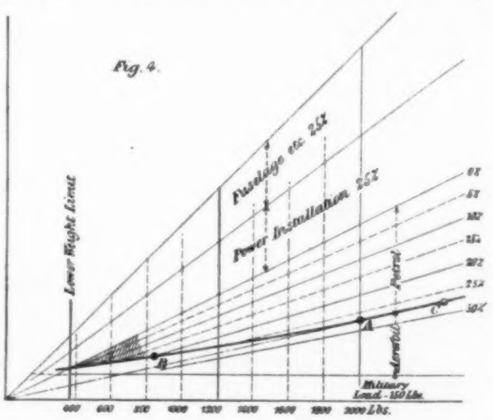
As to the lower limit, first on the question of stability, those best qualified to speak here are in disagreement; the crux of the matter is whether or not *inherent* stability is necessary or desirable. Ever since the formation of the Advisory Committee for Aeronautics in 1909 there has been a battle, if one may say so, in prog-



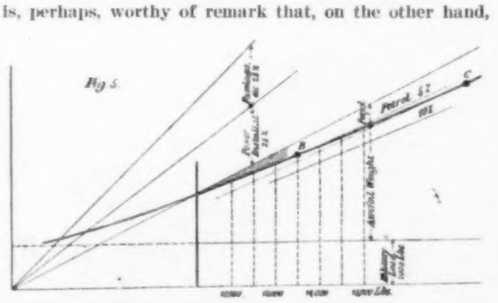
ress between the scientific constructor and the flying man; but the difference of opinion between the two is becoming less as time goes on. The scientific constructor, who has from the first maintained that machines should possess inherent stability, has virtually won the day. This, it may be said, is largely due to the efforts of the late Mr. T. E. Busk, who himself became a pilot in order to prove the then pilot's view as wrong. Briefly put, the argument of the pilot was that a machine with



inherent stability was less readily controlled than one which was neutral or actually unstable; further, that the inherently stable machine of necessity requires to be hand-controlled when alighting under difficulties, and if the pilot thus of necessity has to rely upon his own skill on occasions, it is better that he should always have to do so than only occasionally. The arguments on the other side, however, have proved too strong for this point of view to hold; the fact that an inherently



stable machine will fly itself through clouds and in the dark, and has its own sense of the *true plumb* as distinct from the *apparent plumb*, means that it is at an enormous advantage under many conditions which have to be faced by the military machine. Beyond this, for plain straightforward flying, the inherently stable machine requires comparatively little skill, and does not wear down the pilot under bad weather conditions. It is, perhaps, worthy of remark that, on the other hand,



there are particular cases in the military use of aeroplanes under which the conditions are better fulfilled by a machine whose stability is imperfect; but this is a case for a special type of machine for particular duties rather than an argument against inherent stability as a general proposition. From the standpoint of the present article it is enough to state that the smaller machine is at a great advantage over the larger one on the score of stability. From the meteorological point of view (apart from stability) both large and small machines are on the same footing as to the minimum flight velocity. There is a certain agreed maximum wind velocity which the machine must be capable of exceeding in such ratio as will not too greatly upset calculations as to its time of flight. From the purely military point of view also the large and small machines are on approximately the same footing as to the lower limit of their designed velocity. The question here is mainly that of *pursuit* and that of a *moving target*. In the latter respect the smaller machine has some advantage owing to its ability to dodge more rapidly. Therefore it might be tolerated if its speed were slightly lower; however, this is hair-splitting. It may be said broadly that, from both the meteorological and military point of view, the minimum velocity admissible is independent of the size of the machine.

Now, as to the maximum velocity limit. Here, whether we consider the matter from the point of view of size of flight ground or from the point of view of the horse-power weight factor, the large and small machines are on, roughly, the same footing. It is quite true, however, that, for a given *horse-power/weight* factor, the large machine is capable of somewhat greater speed; the extent of this advantage, however, in any designs which have been so far produced is not great. It is impossible to take account, as a generalization, of this advantage; it is due to the possibility of a relative reduction in the body resistance. In practice, however, the designer can make his own estimate, and calculate, in view of the higher speed, what his reduction of span will be, and what saving in aerofoil weight this represents; he can then apply a suitable correction to the aerofoil weight curves given in Figs. 3, 4, and 5, and from this he will be in a position to compute to what extent it will pay to increase his gross weight for a given duty over that given by the uncorrected diagram. The writer will say here that in any case with which he is acquainted this will only amount to a moderate correction, and can in no case invalidate the method or general results.

It is thus abundantly clear that, for the purpose of broad theory, the assumption of constant flight velocity, no matter what the size of the machine may be, is fully justified. It is, however, of interest from two points of view to show the effect of designing for different velocities. First, we may take it that the weight of the gasoline motor per horse-power may be reduced by advance in knowledge and experience. The gross weight allotted to the power installation in Figs. 3, 4 and 5 may then be reduced, or alternatively the power of the given installation can be increased, and the flight velocity augmented accordingly. In the former case the solution is given by the general theory enunciated, assigning a different proportion of the gross weight in Figs. 3, 4, and 5, by giving a different inclination to the line from which the zero of gasoline capacity is measured, thus increasing the gasoline capacity to the extent of the weight saved from the improved power installation. In the diagram so modified, to comply with the new conditions, the minimum point is not affected.

If, on the other hand, the weight saving takes the form of additional motive power, then the designed flight velocity may be increased (but only with the provision of better flight grounds), and investigation shows the effect of this as an alteration in the scale of the diagram. The basis of scale alteration here is, if V = velocity of design in feet per second, multiply the scale value of W as given by $\frac{V^2}{8000}$, or, assuming biplane construction, alternatively by $0.7\,\frac{W}{s^2}$, where s is the span in feet.

It is of interest to take the case of a designer who, ignoring the considerations discussed in the preceding paragraphs, decides to maintain a constant span with increase of size and to furnish greater horse-power, and fly appropriately faster. If he takes this course, it is easy to show that his aerofoil weight now increases approximately as the gross weight, so that in the diagram the aerofoil weight may now be defined by a straight line directed from the origin O_1. The horse-power required for any given *resistance/lift* factor, however, and consequently the weight of the power installation, now goes up as $W \times V$, and since V increases as $\sqrt{W}$, the rate of the horse-power installation increases as $W\sqrt{W}$, or as $W^{\frac{3}{2}}$. Thus the position is fairly represented by a transposition in the interpretation of the construction given in Figs. 3, 4, and 5; the quantity formerly representing the power installation now represents aerofoil weight, and the quantity formerly representing aerofoil weight now represents power installation, and thus the big machine is at the same disadvantage as previously:

Special Steels*

With Particular Regard to Their Use in Motor Vehicles

By Samuel I. Hoyt.[1]

This paper has a more direct bearing on the special steels used in automobile service than elsewhere. However, I understand that the demands made on special steels by gas tractor practice are in most cases similar to those made by automobile service. At any rate, the advantages possessed by the special steels over the ordinary carbon steels apply with equal force to the two services. Materials for certain tractor parts would be selected with reference to abrasion resistance, especially at somewhat elevated temperatures, whereas in automobile service material for the same parts would be selected with particular reference to its dynamic toughness.

Nickel Steel.—The first important special steel, of the type used in automobile practice, was nickel steel; in fact, the nickel steel first described by Riley in 1889 was an entirely new type of special steel, the special steels up to that time being those used for tool steel, etc.

The nickel is added for two reasons—first, on account of the strengthening effect, as 3½ per cent nickel increases the elastic limit of carbon steel by 50 per cent; and second, the dynamic toughness, as shown by fatigue tests and the notched bar impact test, is double that of carbon steel. It must be pointed out, however, that this great improvement in properties can be secured only by use of a proper heat treatment.

Chromium Steel.—Chromium steel was introduced by Mushet in the 60's in England and by Bauer in New York at about the same time. Its most noteworthy effect on carbon steel is the increase in hardness produced, but the elastic limit like that of nickel steel is also in excess of the elastic limit of carbon steel. Chromium also improves the physical structure of steels by making them finer grained. This has the effect of offsetting the lack of ductility of chromium steels which is evident from the relatively lower elongation and reduction of area. In this way chromium steel furnishes an example of the fallacy of judging steels by static tests alone, as the real toughness of construction steel is brought out only by tests such as the dynamic tests and notched bar impact tests.

Chrome-Nickel Steel.—Here we come to the most renowned of all automobile steels. In considering the effect of adding chromium and nickel to carbon steel, let us consider first the nickel and then the chromium. Nickel on being added to carbon steel dissolves almost entirely in the ferrite and the effect is to increase the elastic limit. The second influence is that of decreasing the grain size which causes a marked increase in toughness which I have already referred to. Chromium, on the other hand, forms a double carbide with iron and the effect of adding chromium to nickel steel is to increase the hardness by means of the double carbide. In this way chromium raises the elastic limit and elastic ratio of nickel steel, but does not destroy its toughness.

Hence it is clear that chromium and nickel added together to carbon steel increase, very materially, the elastic limit, the elastic ratio, the dynamic toughness, and the hardness. This steel is an excellent example of the manner in which one special element can reinforce another special element when added to carbon steel and combine to produce a much superior steel. There are numerous steels on the market which have equal or even better static properties, but it is doubtful if they are equally capable of standing up in service, on account of the difference in dynamic properties.

Chrome-Vanadium Steel and Chrome-Nickel-Vanadium Steel.—Vanadium added to chromium steel and chrome-nickel steel produces an increase in toughness due to the fact that it makes them finer grained, more uniform, and more susceptible to heat treatment. The chrome-vanadium and chrome-nickel-vanadium steels are classed with the chrome-nickel steels as being the best construction steels as yet developed for this type of service.

Silico-Manganese Steels.—Certain types of silico-manganese steels have been developed which possess exceptionally high elastic limits and which can resist vibratory stresses and therefore are useful as springs.

Tungsten Steels.—Tungsten steels are used originally as tool steel on account of their great hardness, but they also possess a property which makes them of use in automobile service; viz., that of resistance to abrasion at elevated temperatures. On this account they are used for valves.

The advantage of the special steels over the carbon steels for use as construction steel is due, more than to anything else, to the increase in toughness which is secured, especially dynamic toughness. The carbon steels can be made appreciably stronger by increasing the carbon content and by heat treatment, but they would be made brittle and therefore of no use. The special steels, however, can be made strong and tough at the same time.

The increased toughness can be utilized in three different ways, according to Le Chatelier:

1.—Maintaining the same strength and toughness, the parts can be made appreciably lighter. This is of great importance in automobile construction where weight is of prime importance, especially as far as speed, endurance, economy, and upkeep are concerned. The diminished weight is also an important factor in the cost of production as the extra cost of the special steels is oftentimes more than balanced by the lower manufacturing costs due to the lower weight. In gas tractor service a saving in the weight of the parts, especially the moving parts, lessens the sudden strains which are imposed by forced stopping and other irregularities in the service. But the advantages of using light weight parts in place of heavy parts comprise not only the saving in handling the material on the floor, in machining and in assembling, but also the advantages derived by the buyer.

2.—With the same weight and toughness the parts can be more heavily loaded. This lessens the danger of overloading which often results in deformations sufficient to put the overloaded part out of service.

3.—With the same weight and strength much greater toughness can be secured which amounts to insurance against accidents and failures.

In what is presented above, I have referred not to static toughness as determined by static tensile tests, but to dynamic toughness as determined in dynamic and impact tests. In fact a great mistake is made by judging the value of special steels by means of static tests alone, not only that the relative values of special and carbon steels are not brought out, but that at times the results of static tests are directly misleading. This is not a pleasant thought for him who would go to but little trouble and expense in testing construction steels, but it is a fact and as such must be squarely met.

I wish to repeat another important point in connection with the production and use of special steels; viz., in order to make special steels worth while to justify the increased cost, they must be properly heat treated. This is a subject which has not as yet, at least in our country, received the attention which it deserves and which in the future is bound to be paid to it. This neglect is due, I believe, not only to the fact that the special steel industry is in its infancy, but also to the special difficulties of a scientific nature involved, both in the determination of the proper heat treatment to be employed for each particular case and in properly carrying out the heat treatment of the parts concerned.

Also I might add that the solution of the problem lies in two directions. The users of special steels, such as gas tractor and automobile manufacturers, must be awake to the possibilities of such use. In other words, the manufacturer must create a demand for a superior product in order that he may produce a more salable, a more durable, and a more economical machine. But it is also necessary for the maker of special steels, not only to produce high grade steels of the proper chemical analysis, but he must also know the kind of steel to be used and, what is more important, the proper heat treatment to suit the individual requirements.

Whether the maker of the steel, the manufacturer or a middle-man shall actually perform the heat treating, depends on which one is best equipped to do that kind of work. Of prime importance is that the heat treatment be properly done. In other words, the steel maker should advise with the manufacturer and tell him which steel is best suited for his particular purposes, all things considered, and what heat treatment is necessary in order to bring out the desired properties.

From my own experience I cannot say that this ideal state of affairs exists in the United States. As a matter of fact, the steel makers, as represented by their salesmen, while ready at all times to recount the virtues of their special steels, seem to possess little serviceable information for the purchaser and transactions are carried on largely on a basis of the static properties. One cannot wonder that many manufacturers feel that special steels are but an expensive luxury.

Next the kinds of steel used for different parts will be taken up briefly and, incidentally, I shall have a few words to say about case hardening practice.

Axles.—It falls to the lot of axles to receive some of the severest strains which are encountered. Axles must be statically strong (high elastic limit), dynamically tough, and, if poor design or workmanship must be considered,[2] they should also have both high static and dynamic notch toughness. Toughness is secured by nickel and vanadium while strength is secured by nickel and chromium so that the steels to be recommended for axle service are nickel, chrome-nickel, chrome-vanadium, and chrome-nickel-vanadium steels.

Crank-Shafts.—Many times it is desirable to reduce the weight of the crank-shaft and at the same time maintain a certain degree of toughness and stiffness. If so, it is advisable to use chrome-nickel or chrome-vanadium steel, but, of course, the heat treatments would be different from those for axles. The requirements for this service are high resiliency in combination with comparatively low elongation so that heavy impacts can be absorbed without causing serious deformations in the crank-shaft.

Cam-Shafts.—The duty is naturally lighter on cam-shafts than on crank-shafts and axles, but a saving in weight can be effected by using nickel, chrome-nickel, or chrome-vanadium steel.

Gears.—Many heat treated gears are being used in place of case hardened gears. The combination desired is hardness and toughness, two properties which are difficult to combine in any one piece. However, a greater degree of toughness can be secured with the same hardness by using special steels. The chrome-nickel, chrome-vanadium, and chrome-silico-manganese steels are used for this purpose.

Springs.—Springs require a combination of high elastic limit and high dynamic resiliency, and of course dynamic toughness. Springs and crank-shafts share the property of high dynamic resiliency in common. The difference for these two services is that in one case the permissible deformation is very small, while in the other case it is necessarily large. The steels used for springs are chrome-vanadium and a special type known as silico-manganese.

Frames.—Frames must be tough and have high resistance to vibratory stresses. Nickel, chrome-nickel, and chrome-vanadium steels are used extensively for this work.

Steering Arms.—Steering arms are subject to a combination of stresses which is probably more complex than the strains on the other parts. For this reason the design and workmanship of steering arms are especially important. The steels used are nickel and chrome-nickel.

Roller Bearings.—Roller bearings must be hard and yet not too brittle. There have been two types of steels developed for this work, viz., the high carbon-high chromium steel and chrome-vanadium steel oil-hardened.

Valves.—If a special steel is desired for valves, it is usually tungsten steel, but certain high nickel steels are also used.

Case Hardening Practice.—The first step in the process of case hardening is annealing in the case hardening mixture or "cement" for a sufficient length of time and at a sufficiently high temperature to produce the case desired. The second step is called the first quenching which has as its object the regeneration or toughening of the core. The third step is the second quenching which has as its object the hardening of the case. There are many advantages secured by using the special steels and I shall mention several of them.

1.—Certain of the special types are much less affected by the first annealing process than the carbon steels. That is, the annealing produces a much smaller growth in grain size which in itself, aside from the greater natural strength and toughness of the special steels, retains a greater tenacity and toughness in the core.

2.—Certain special steels permit a modification of the heat treatment so that the first and second quenchings can be combined into one treatment which is so calculated that it is satisfactory for both the case and the core.

3.—The results are rendered more certain by using special steels; i. e., the case can be made more uniform and harder while the core can be made stronger and tougher.

*Paper presented at the Minnesota local section of the American Society of Mechanical Engineers and published in the *Journal* of the Society.

[1]Assistant Professor of Metallography, The University of Minnesota.

[2]It has come under my personal observation that both of these points require serious consideration.

4.—Deformations due to quenching can be more easily avoided with certain special types of steels, for instance, the air hardening steels. These steels belong to a class of steels that is not generally manufactured at present in the United States, and should not be confounded with tool steels.

5.—A higher carbon content can be permitted in the core without losing the property of toughness. An example is furnished by the chrome-nickel steels with which a carbon content of 30 per cent can be used, a steel which also produces a hard case suitable for parts subject to wear and shock.

6.—In carbon steels two of the constituents, ferrite and cementite, have a habit of forming in relatively large crystals, the presence of which is dangerous on account of the brittleness and liability of exfoliation produced thereby. This can be eliminated by using special steels.

7.—The use of special steels greatly increases the efficacy of the treatment.

The parts which are commonly case hardened are cam shafts, roller bearings, and gears. For cam shafts a low carbon, nickel or chrome-nickel steel is used which is case hardened on the wearing surfaces of the cams. For roller bearings, low carbon, nickel, chromium, and chrome-nickel steels are used depending upon the service.

Steels which are quite generally used for gears are low carbon, chrome nickel and chrome-vanadium steels, and it might be added that these steels, case hardened in a practical manner, give a more satisfactory combination of properties than is produced by the heat treated parts, although the expense is somewhat greater.

In the limits of a paper such as this, it is not possible to enumerate the many advantages aside from saving in weight, increased toughness, etc., which are derived from the use of special steels, but I wish to cite, in conclusion, a case which will show at least one of the possibilities.

This example is taken from the work of Guillet, the noted French metallographer. This steel was developed primarily to simplify the heat treatment and in fact it is simply necessary to heat the steel up to about 1,550 deg. Fahr. and allow it to cool in air. This treatment produces the desired properties in the same manner that the double heat treatment does for the carbon steels. The composition of the steel is as follows: C 0.75 per cent, Ni 3.82 per cent, Cr 1.28 per cent, Mn 0.52 per cent.

The properties are given in the following table:

	Tensile Strength	Elastic Limit	Elong. per cent	Elong. R of A. per cent	Resistance to Impact
Annealed	138,000	110,000	12	40	3
Air Hardened...	192,000	188,000	10	20	8

The elongation and reduction of area are less in the air hardened steel, but the resistance to impact is appreciably greater, showing a greater dynamic toughness, the property which serves better than any other to demonstrate the superiority of special steels over the carbon steels.

The Utilization of Cull Citrus Fruits*

Suggestions for Saving a Natural Product That Is Now Largely Wasted

By F. Alex. McDermott

In the packing of citrus fruits a considerable proportion of the fruit coming into the packing houses is unfit for shipment, and must be discarded; this discarded fruit constitutes the culls, and may amount, during poor seasons, to as much as 10 per cent of a given lot of fruit, though ordinarily the proportion is not so high. The usual causes of culling are extreme over- and under-size, stem-end rot, traumatic injuries to the peel, and blue molds. A few of these culls are disposed of at low prices for quick sales in the local markets, while a good proportion are consumed by the local cattle or simply allowed to decay on the ground. A considerable number of these culls have the flavor and food value unimpaired, if utilized immediately. The main problems offered were (*a*) to find a satisfactory process by which the juice of these culls could be preserved for at least two years, without conflict with the national or State pure food laws, and (*b*) to develop a method by which the flavoring oil could be removed from the peels in such a manner that the product would meet the commercial requirements for such an oil, and could sell as a domestic product, in competition with the imported Italian oil. The recovery of the citric acid formed one of the minor problems.

A large number of experiments were made with different processes to determine their effect on the stability of the juice. As had already been observed, it was soon found that simple pasteurization of the juice was not sufficient to protect it from further change; for a short time after pasteurization, usually less than two weeks, the juice kept without apparent change, but after the lapse of this time a change of color became evident, the juice darkening and finally becoming muddy; this change in color was accompanied by a deterioration in flavor, which eventually became offensively acrid. All specimens did not change to the same degree, but it was found impossible to correlate this difference between specimens with differences in acidity or sugar content. Such darkened specimens appeared to be sterile, no organisms being shown by inoculations on standard agar or on sterilized orange juice, or under microscopic examination. The effect seemed to be due to chemical action, but although a large number of tests were made, these failed to indicate just what change had taken place in the darkened juice. It was found, however, that the removal of the air dissolved in the juice and that in the container above it, followed by pasteurization, was sufficient to prevent this deterioration of the juice for a considerable time—in fact, all failures which occurred within two years could be traced to air having gained access to the juice through leaks which developed in the stoppers on long standing under varying conditions of temperature. It was found, further, that, as would naturally be expected, it was the oxygen of the air which was active in producing this change, although replacing the air with pure oxygen did not produce as rapid and strong a darkening as would be expected, the effect being but little different from that of air alone.

It may be of interest to note here that the most common organized contamination of orange juice which was encountered in this work was a strain of the wild yeast ("Kahmhefe") *Willia anomala*, and it is this organism which is responsible for the development of the ester odor (apparently ethyl acetate) which may so frequently be noticed in orange juice which has stood some hours at room temperature; the yeast was kindly identified for me by Dr. Alb. Klöcker of the Carlsberg Laboratory, Copenhagen. Acetic acid bacteria were also found occasionally, in every case observed being secondary to the wild yeast, and on long standing various molds developed. The common blue molds of the peel of the orange, *Penicillium italcum* and *P. olivaceum*, appeared to be unable to grow on the sterilized juice, and all attempts to inoculate them directly from infected fruit on this medium resulted instead in the growth of the *Willia*.

The simplest method of effecting the removal of the air from and above the juice in the containers seemed to be to replace it by some non-oxidizing gas, and of those commercially possible, carbon dioxide appeared to be the best. A very large number of specimens of orange and grapefruit juices were prepared, in which the juice was charged with carbon dioxide at atmospheric pressure, and the air above the liquid replaced with the dioxide; the bottles were then sealed with paraffined stoppers, pasteurized, and the joint between the stoppers and the necks kept covered with paraffin while cooling. This system of sealing, while by no means perfect, gave a considerable number of specimens which remained without apparent change for two years or more. Charging with CO_2 under pressure, without removal of the air present, did not afford protection against deterioration. It was found that pure nitrogen, hydrogen or methane (washed natural gas) gave as good results, so far as preservation was concerned, as did the carbon dioxide, but owing to their lower solubility they were somewhat more difficult to deal with than the dioxide. Nitrous oxide, as might be expected, gave results about like those of pure oxygen. So far as flavor is concerned, the hydrogen was superior to any of the other gases, though, of course, harder to handle. The carbon dioxide gave a slightly unnatural tang to the juice, suggesting incipient fermentation to some who tasted it.

Sealing *in vacuo* was also tried, and eventually proved to be the most satisfactory method of meeting the difficulty. Early experiments using sealing bottles showed that the juice retained its flavor best when pasteurized under as complete a vacuum as possible, the usual process being to exhaust the container to about 28.5 inches vacuum, while immersed in water at a temperature slightly above the boiling point at this pressure; the contents were then allowed to boil a little while under the reduced pressure, to drive out dissolved gases, the liquid then cooled, and the bottle sealed. Such preparations kept excellently, as long as the bottles remained sealed; breakage of the seal was followed by discoloration and deterioration of flavor, as in the fresh juice. Later experiments were made using the method of vacuum sealing with a rubber gasket and cap, which has been so widely applied recently in the preparation of food products, especially by the Beech Nut Company. It was found that equally good results were obtained, the main difference in operation being that the juice in the container was heated to a point slightly above that at which it would boil at the vacuum employed, then the container placed in the sealing machine, exhausted, ebullition permitted for a minute or so, and then the jar sealed and pasteurized. Of course, these seals fail occasionally, and such failures were always evidenced by discoloration of the juice.

What has been said heretofore has referred mainly to orange juice; the juice of the grapefruit undergoes exactly the same discoloration and change of flavor, on simple pasteurization in air, as does the orange juice. Lemon juice, however, seems to be a somewhat different proposition, as it is reported in the literature that repeated simple pasteurization is all that is necessary to prevent deterioration; no direct experiments were made with lemon juice, but it was found that the repeated pasteurization (pasteurized at 63-65 deg. Cent. on two or even three successive days) was insufficient to inhibit this change in orange juice.

The temperature of pasteurization is an important factor in the flavor of the juice. Temperatures below 60 deg. Cent. were insufficient to prevent the development of the spores of *Willia*, and with subsequent fermentation, while at temperatures above 70 deg. Cent. the flavor began to be noticeably that of cooked juice, and lacked the freshness of the untreated product. Pasteurization at 63-65 deg. Cent., for 15 minutes, provided the entire volume of the juice reached that temperature, gave the most satisfactory results, so far as flavor was concerned. Sterilizing at 100 deg. Cent. and autoclaving at pressure are out of the question when preservation of the natural flavor is to be considered; autoclaving without the replacement of the air by a non-oxidizing atmosphere usually caused immediate darkening, in addition to the deterioration of flavor.

For the best flavor it was found that all of the fruit should not be peeled before expressing the juice; the juice from all peeled fruit was flat and uninviting, but if 5 to 10 per cent of the oranges were left unpeeled, the juice had about the correct flavor. Of course, the addition of the expressed oil from the peel is possible, but experiments indicated that this did not give as satisfactory a flavor as the retention of unpeeled fruit in the lot to be pressed. For grapefruit juice, it was found necessary to peel completely all the fruit, and to supply the flavoring by adding 5 to 10 per cent of unpeeled oranges; retention of the grapefruit peels produced a liquid of extreme bitterness.

The clarification of the juice is a serious problem. For commercial purposes it would seem best that the juice be nearly clear, although this is not a natural condition for orange juice. The juice, however, does not yield readily to the ordinary methods of clarification or filtration; of many methods tried, the best results were obtained with DeLaval clarifiers, the juice being taken first through a clarifying bowl to remove the greater part of the suspension, and then through a filtering centrifuge. The liquid so obtained is not water-clear, but contains comparatively little suspension. An alternate procedure is to pasteurize out of contact with the air in large containers, and allow to settle, then draw off the clear supernatant liquid after several weeks, bottle like fresh juice, and treat the

* Author's abstract of a rather extensive report on the utilization of the cull citrus fruits from the packing houses in Florida, coveringg the author's work on this subject during the period from October, 1911, to August, 1913, under the auspices of the Florida Citrus Exchange, at the Mellon Institute of Industrial Research, of the University of Pittsburgh. Publication has been withheld, up to this time, in accordance with the fellowship agreement; complete publication of the entire report will be made at a later date. Republished from *The Journal of Industrial and Engineering Chemistry*.

residue by centrifugal methods. Chemical clarification by means of formaldehyde or alcohol is possible, but obviously not desirable.

Both orange and grapefruit juices may be evaporated under conditions of greatly reduced pressure, to a thick sirup, and this sirup may, in either case, be dried to a brittle, glassy and very hygroscopic solid. It is essential for the retention of a good flavor, however, that the temperature in these evaporation and drying processes shall at no time exceed 60 deg. Cent., which condition makes the drying extremely slow. The products so obtained may be dissolved in water, and beverages thus made up from them; it cannot be said that the flavor of these beverages is quite up to the standard of fresh juice preserved as above indicated, but it is still quite close to the normal taste of orange juice, if the evaporation has been carefully done. Of course, the vacuum treatment removes the flavoring materials from the juice, and it is necessary to add oil for flavoring purposes, better at the time of making the beverage than before pasteurization in the vessel. The concentrated juice will keep under the same conditions as the fresh, i. e., after pasteurization in the absence of free oxygen; the dried material cannot be pasteurized, as it fuses together at pasteurizing temperatures, but pasteurization is not necessary, provided water and air are excluded.

There is a considerable literature, especially of patents, regarding the preservation of fruit juices, but it is thought inexpedient to include any of these references in this abstract.

The recovery of the flavoring oils from the peels of citrus fruits is at present carried on mainly by rather crude methods in Italy and Sicily, under conditions of cheap labor with which American packers cannot compete. A process for recovering this valuable oil from the peels of Florida oranges must therefore be one which will handle a large number of peels at very little cost. Various mechanical methods of pressing, rolling, abrading, etc., were tried without much promise of success. Soaking methods, in which the ground peel is covered with water, to the surface of which the oil rises and is there drawn off, gave low yields of fair quality oil, but while simple, these processes are rather inefficient. After considerable experimentation it was found that a very satisfactory oil could be produced by grinding the peel, submitting the ground material to a current of water vapor at greatly reduced pressure and condensing and separating the oil. Ordinary Florida oranges yielded about 0.5 cubic centimeter of oil per peel, while the late Valencias gave from 1 to 1.5 cubic centimeters per peel. The liberation of the oil appears to be favored by previous partial drying of the peel. The oil obtained from Florida oranges as above indicated, has been used repeatedly in cakes and candies, when dissolved in alcohol, and has given excellent results. It appears to be up to the requirements of the existing legislation.

As is well known, the flavoring oils from citrus fruits rapidly deteriorate on exposure to the air, especially in the light, acquiring a very offensive turpentine-like odor. It was found during this research that this could be obviated by the addition to the oil of about 10 per cent by volume of absolute alcohol; oil so treated was allowed to stand exposed to diffused daylight at room temperatures for many months without deterioration. It is not to be recommended, however, that such oils be kept under these conditions; keeping in the dark in a cool place is far better, even with protecting agents present. The use of 1.5 to 2 per cent of olive oil has also been recommended for this purpose; this gives some protection, but is not as good as the alcohol. Sealing in an atmosphere of carbon dioxide is also effective in protecting the oil for a long time. On the whole, however, the addition of absolute alcohol gave the best results, and it seems that it would be well to admit of this treatment of such oils for their preservation in the United States Pharmacopoeia and other standards.

The recovery of the citric acid from the juice of Florida citrus fruits (for the sake of the acid alone) is scarcely worth while, in view of the small amount available, rarely over 0.7 per cent in the orange, or 1.5 per cent in the grapefruit. As a matter of scientific interest, however, it was found that Wehmer's *Citromyces* molds would grow on the sterilized juice in the presence of calcium carbonate, and convert a considerable proportion of the residual sugar into citric acid. The commercial application of such a process seems rather hypothetical.

From the results of this investigation it appears, then, that the preservation of the juice of the orange and grapefruit is practicable, the method depending on pasteurization out of contact with air, and that the recovery of the flavoring oil from the peels may be accomplished commercially by methods of vacuum distillation, but that the recovery of the citric acid for itself alone is not practicable.

Since this abstract was prepared, a valuable and interesting paper by Will has appeared, relating to the utilization of these culls in the California citrus industry.

Engineers and the Law

THE modern engineer has to know a great deal more than mere engineering. This is being realized at certain of our universities, where, in addition to the usual engineering courses, students are required to take courses of lectures in the Faculty of Commerce to enable them properly to understand the business side of their profession. As far as we know no British university yet requires its engineering undergraduates to take a short course of law, but so many and close are the points of contact to-day between the law and engineering that it would seem to be eminently desirable for a study of the inter-relation of these two subjects to form part of the curriculum of the modern university.

Lord Fletcher Moulton has very clearly summarized the general relation of law to engineering in the following words: "The profession of an engineer involves much more than mere engineering knowledge or even executive skill. In a large proportion of the matters in which he is consulted he has the responsibility of giving advice, and that advice often relates to acts in which the rights of third parties are directly or indirectly involved. This consideration alone would make it desirable that he should have a sound knowledge of such branches of the law as bear upon the questions he has to resolve. But his need of clear legal conceptions does not depend on this alone. He has not only to administer, but often to frame, contracts of a character which, beyond doubt, renders them the most complicated of any that have to be interpreted and pronounced upon by our courts, and their nature is such that he can only pass on the responsibility to professional lawyers to a small extent. The rest deals with matters so technical that it must remain in his hands."

In an excellent paper on the subject of law and engineering which he read at the last meeting of the Society of Engineers, Mr. Sydney G. Turner, himself a barrister-at-law as well as a qualified engineer, gave many interesting examples to show how engineers, whether they be civil, electrical, hydraulic, or municipal, are frequently confronted with puzzling legal problems.

New methods of road construction and treatment have to receive careful consideration from the legal as well as the technical side by municipal engineers. Mr. Turner mentions some interesting cases dealing with the liability of a local authority for damage caused by the manner of repair, e. g., by the use of tar, which are of peculiar interest at the present time. The leading case is West vs. the Bristol Tramways Company, 1908, 2 K. B., 14, where the plaintiff, a market gardener, successfully claimed damages for injury to plants and flowers caused by the fumes emanating from creosoted wood-paving. The case was decided on the ground that the defendants had no statutory authority to use creosoted wood, but that their only statutory obligation was to pave, and a material which would not have caused damage might have been used. In these circumstances, having elected to use creosoted wood, they did so at their peril, and consequently were held liable for the damage caused. The principle of this case has since been applied in a case against the Kent County Council (decided in the County Court), where a cow was killed through drinking water which had been polluted by tar washed from road surfaces. In this case, as in the Bristol case, it was held that the treatment of the road with tar was not the only method available, and was not, therefore, absolutely necessary.

In connection with electric lighting undertakings—as in the case of gas and water works—questions of procedure and also points relating to the breaking up of streets arise; while in connection with tramways and light railways further questions at once suggest themselves. As an illustration, the recent case of the Charing-cross, West-end, and City Electricity Supply Company vs. the London Hydraulic Power Company, 1913, 3 K.B. 442, is referred to by Mr. Turner. This was an action brought by the plaintiff to recover damages for injury to their cables in four different streets caused in each case by the bursting of the defendant's mains. The bursting of the mains was not due to any negligence on the part of the defendant, and the question for decision was whether they were under any liability as for nuisance. Two of the mains were laid under a private Act which was silent as to liability for nuisance, but the other two had been laid under a later Act, which contained a clause to the effect that nothing in the Act should exempt the company from liability for nuisance. The latter Act further provided that the two Acts should be "read and construed together as one Act." It was held that the defendants were liable as for nuisance in the case of the two mains laid under the later Act; and, further, that the effect of the two Acts being read together was to take away any privilege of the defendants under the earlier Act, and that consequently they were also liable as for nuisance in the case of the two mains laid under that Act.

In concluding his very suggestive remarks, the author refers to the number and variety of the subjects in regard to which the lawyer and the engineer may meet on common ground; and further suggests the desirability of establishing some periodical meeting, open to the members of both professions, at which such subjects could be discussed. Such a meeting should be of great mutual assistance.—*London Daily Telegraph.*

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